

FORM PTO-1390 (REV. 5-93)		U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE		ATTORNEY'S DOCKET NUMBER NIP-208	
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US)				U.S. APPLICATION NO. (if known, see 37 CFR 1.5)	
				09/674008	
International Application No. PCT/JP99/02207		International Filing Date April 26, 1999		Priority Date Claimed April 28, 1998	
Title of Invention OPTICAL MEASUREMENT INSTRUMENT AND OPTICAL MEASUREMENT METHOD					
Applicant(s) for DO/EO/US A. MAKI et al (SEE ATTACHED LIST)					

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

- ☒ This is a FIRST submission of items concerning a filing under 35 U.S.C. 371.
- ☐ This is a SECOND or SUBSEQUENT submission of items concerning a filing under 35 U.S.C. 371.
- ☒ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
- ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
- ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
  - ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
  - ☒ has been transmitted by the International Bureau.
  - ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
- ☒ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
- ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
  - ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
  - ☐ have been transmitted by the International Bureau.
  - ☐ have not been made; however, the time limit for making such amendments has NOT expired.
  - ☐ have not been made and will not be made.
- ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
- ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
- ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern other document(s) or information included:

- ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
- ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
- ☒ A FIRST preliminary amendment.  
☐ A SECOND or SUBSEQUENT preliminary amendment.
- ☐ A substitute specification.
- ☐ A change of power of attorney and/or address letter.
- ☒ Other items or information:  
[X] LIST OF INVENTORS' NAMES AND ADDRESSES.

U.S. Application No. (if known, see 37 CFR 1.5) <b>09/674008</b>	International Application No. PCT/JP99/02207	Attorney's Docket Number NIP-208
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17. ☒ The following fees are submitted:Basic National Fee (37 CFR 1.492 (a)(1)-(5)):

Search Report has been prepared by the EPO or JPO ..... 860.00

International preliminary examination fee paid to USPTO (37 CFR 1.482) ..... \$670.00

No international preliminary examination fee (37 CFR 1.482)  
but international search fee paid to USPTO (37 CFR 1.445 (A)(2)) ..... \$760.00

Neither international examination fee (37 CFR 1.482) nor  
international search fee (37 CFR 1.445(A)(2)) paid to USPTO ..... \$ 970.00

International preliminary examination fee paid to USPTO (37 CFR 1.482)  
and all claims satisfied provisions of PCT Article 33(2) to (4) ..... \$ 96.00

CALCULATIONS PTO USE ONLY

ENTER APPROPRIATE BASIC FEE AMOUNT = \$ 860.00

Surcharge of \$130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30  
months from the earliest claimed priority date (37 CFR 1.492(e)). + \$ 0.00

Claims	Number Filed	Number Extra	Rate	
Total	15 -20 =	0	x \$18.00	\$ 0.00
Independent	8 - 3 =	5	x \$80.00	\$ 400.00

Multiple dependent claim(s) (if applicable) + \$270.00 \$ 0.00

TOTAL OF ABOVE CALCULATIONS = \$ 1,260.00

Reduction by 1/2 for filing by small entity, if applicable. Verified Small Entity statement  
must also be filed. (Note 37 CFR 1.9, 1.27, 1.28). \$ 0.00

SUBTOTAL = \$ 1,260.00

Processing fee of \$130.00 for furnishing the English translation later than ☐ 20 ☐ 30  
months from the earliest claimed priority date (37 CFR 1.492(f)). + \$ 0.00

TOTAL NATIONAL FEE = \$ 1,260.00

Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be  
accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). \$40.00 per property. + \$ 0.00

TOTAL FEES ENCLOSED = \$ 1,260.00

Amount to be:  
Refunded \$  
Charged \$

- a. ☒ A check in the amount of \$ 1,260.00 to cover the above fees is enclosed.
- b. ☐ Please charge my Deposit Account No. 50-1417 in the amount of \$ \_\_\_\_\_ to cover the above fees.  
A duplicate copy of this sheet is enclosed.
- c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any  
overpayment to Deposit Account No. 50-1417. A duplicate copy of this sheet is enclosed.

**Note:** Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive  
(37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

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NIP-208

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of

A. MAKI et al

Serial No.

Filed: October 24, 2000

For: OPTICAL MEASUREMENT INSTRUMENT AND  
OPTICAL MEASUREMENT METHOD

**PRELIMINARY AMENDMENT**

Assistant Commissioner of Patents  
Washington, D.C. 20231

Sir:

Prior to examination, please amend the above-identified  
application as follows.

**IN THE CLAIMS**

Please amend claim 16, and delete claims 15, and 17-19.

16. (Amended) An optical measurement [method] system  
comprising functions of:

performing an initial display process for  
selectively instructing any one of selection of optical  
measurement, analysis of said optical measurement result and  
completion of a program;

[a process for] inputting items of condition  
including a measurement mode;

[a process for] displaying a state expressing  
relationship among light irradiation positions and light

detection positions and measurement positions so as to meet said mode;

[a process for] instructing to form a file for storing said optical measurement result;

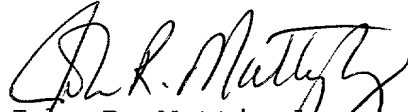
[a process for] instructing a measurement condition to detect light signals from the inside of a body to be inspected which is irradiated by a multi-wavelength multi-channel; and

[a process for] displaying said signals for each channel detected according to said instructing results.

**REMARKS**

Examination is requested.

Respectfully submitted,



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Date: October 24, 2000

Title of the Invention

OPTICAL MEASUREMENT INSTRUMENT AND OPTICAL  
MEASUREMENT METHOD

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## TITLE OF THE INVENTION

OPTICAL MEASUREMENT INSTRUMENT AND OPTICAL MEASUREMENT METHOD

## BACKGROUND OF THE INVENTION

5           The present invention relates to an optical measurement system and an optical measurement method, and particularly, to an optical measurement system which is suitable for optically measuring the inside of a biological body and imaging the inside of the biological body based on information signals obtained  
10 by the measurement.

          A technology of easily measuring the inside of a biological body without affecting any ill effect on the biological body is desired in the field of clinical treatment. Measurement using light is very effective for this desire. The  
15 first reason is that oxygen metabolism inside the biological body corresponds to a concentration of specific pigments (hemoglobin, cytochrome a a3, myoglobin and so on), that is, light absorbents in the biological body, and the concentration of the pigments can be obtained from an amount of absorbed light  
20 (in a wavelength band from visible light to near-infrared light). The second reason is that light can be easily handled using an optical fiber.

          Systems making use of the advantage of biological measurement using light are disclosed, for example, in Japanese  
25 Patent Application Laid-Open No.63-277038, in Japanese Patent Application Laid-Open No.5300887 and so on. In the systems, light having wavelengths from visual light to near-infrared light is irradiated onto a biological body, and an inside of a biological body is measured from the reflected light detected

at a position 10 to 50 mm distant from the irradiated position. Further, systems for measuring a CT image of oxygen metabolism from light transmitted a biological body having a thickness of 100 to 200 mm, that is, optical CT systems are disclosed, for  
5 example, in Japanese Patent Application Laid-Open No.60-72542 and in Japanese Patent Application Laid-Open No.62-231625.

In regard to clinical application of biological body optical measurement, in a case of measuring, for example, a head there are measurement of an activation state of cerebral oxygen  
10 metabolism and measurement of a local cerebral hemorrhage. In regard to cerebral oxygen metabolism, it is possible to measure higher order brain functions from motion, senses to thinking. In such measurement, the effect of the measurement can be increased larger by displaying the measured result as an image  
15 than by not displaying any image. For example, measurement and display as an image is indispensable for detecting a portion where oxygen metabolism is locally changed.

In a multichannel optical measurement system, it is difficult to speedy detect a channel having a problem unless  
20 correspondence between actual measured positions and measured signals is shown to an operator operating the system.

In addition, there have been problems to cause serious results in the field of clinical treatment unless the operator inputs a large amount of measuring conditions before initiating  
25 the measurement.

#### SUMMARY OF THE INVENTION

An object of the present invention is to provide an optical measurement system and an optical measurement method

which is suitable for optically measuring a body to be inspected and easily obtaining an image of a desired item based on information obtained by the measurement.

In order to attain the above object, in the present invention, measuring positions and a layout of optical fibers specific in the multi-channel optical measurement system are presented to an operator using a display portion. Further, by adding a function of changing the displayed layout corresponding to a measuring signal, it becomes easy to understand the status of the channels. Furthermore, in the present invention, a limited number of windows for inputting measurement conditions are displayed on the display portion, and measurement conditions in the next level hierarchy are displayed after completion of the inputting.

#### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram showing the construction of the main portion of an embodiment of an optical measurement system to which the present invention is applied.

FIG. 2 is a flowchart showing an example of processing flow in accordance with the present invention for measuring a body to be inspected using the optical measurement system shown in FIG. 1.

FIG. 3 is a view showing an initial window which is shown on a display portion.

FIG. 4 is a view showing a window for inputting conditions which is shown on the display portion.

FIG. 5 is a view showing a window for displaying gain adjusting underway which is shown on the display portion.



FIG. 6 is a view showing a window for displaying measured positions which is shown on the display portion.

FIG. 7 is a view showing a window for display abnormality which is shown on the display portion.

5 FIG. 8 is a view showing a window for forming a file which is shown on the display portion.

FIG. 9 is a view showing a window for forming a directory which is shown on the display portion.

10 FIG. 10 is a view showing a measurement window which is shown on the display portion.

FIG. 11 is a view showing a sub-menu window of Info of FIG. 10 which is shown on the display portion.

15 FIG. 12 is a view showing a window for inputting measurement conditions and display conditions which is shown on the display portion.

FIG. 13 is a view showing a window of Option of FIG. 10 which is shown on the display portion.

20 FIG. 14 is a view showing a window for displaying a measurement data time sequence which is shown on the display portion.

FIG. 15 is a view showing a window for inputting the display conditions of graph of FIG. 14 which is shown on the display portion.

25 FIG. 16 is a view showing a window for inputting a file backup condition which is shown on the display portion.

FIG. 17 is a view showing a window for input setting of the other measurement equipment output signal which is shown on the display portion.

FIG. 18 is a view showing a window for setting a

rectangular wave output signal which is shown in the display portion.

FIG. 19 is a chart showing the rectangular wave output signals of which the conditions are set in FIG. 18.

5        FIG. 20 is a view showing a window for setting an external input trigger synchronous measurement condition which is shown on the display portion.

FIG. 21 is a view showing a window for setting a measured data acquiring condition which is shown on the display portion.

10       FIG. 22 is a view showing a window for checking a measured signal which is shown on the display portion.

FIG. 23 is a block diagram showing the construction inside the light module of FIG. 1.

15       FIG. 24 is a view showing an example of a geographical arrangement of irradiation positions and detecting positions on a surface of a body to be inspected.

FIG. 25 is a block diagram showing the construction of lock-in amplifier module of FIG. 1.

20       FIG. 26 is a graph showing an example of time variation of a measured signal at a detecting position and time variation of a predicted no-load signal obtained from the measured signal.

FIG. 27 is a graph showing an example of time variation of an amount of relative change in concentrations of oxygenated hemoglobin and deoxygenated hemoglobin at a measurement  
25       position.

FIG. 28 is a view showing a contour image (a topography image) produced from time variation of an amount of relative change in a concentration of oxygenated hemoglobin at each measurement position when motion of left-hand fingers of a

person to be inspected is used as a load.

FIG. 29 is a view showing a contour image (a topography image) produced from time variation of an amount of relative change in a concentration of oxygenated hemoglobin at each measurement position when motion of right-hand fingers of a person to be inspected is used as a load.

FIG. 30 is a view showing an example of a display superposing a topography image on a cerebrum surface image of a person to be inspected.

10

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 is a block diagram showing the construction of the main portion of an embodiment of an optical measurement system to which the present invention is applied. The present embodiment is that light is irradiated, for example, on the skin of a head and then light penetrating into and scattered by the body is detected from the skin to image the inside of the cerebrum. In the embodiment, number of measurement channels, that is, number of measurement positions is 12. Of course, the object to be measured is not limited to a head, and the present invention can be applied to the other portions and to an object other than a biological body.

A light source portion 1 is composed of four light modules 2. Each of the light modules is composed of a plurality of semiconductor lasers each emitting light having a different wavelength within a wavelength band from visual to infrared, for example, two semiconductor lasers each emitting light having either of 780 nm or 830 nm wavelength. These values of two wavelengths are not limited to 780 nm and 830 nm, and number

of wavelengths is not limited to two. In regard to the light source portion 1, light emitting diodes may be used instead of the semiconductor lasers. The light from all of the eight semiconductor lasers contained in the light source portion 1 is modulated by a oscillating portion 3 composed of eight oscillators having different oscillation frequency, respectively.

FIG. 23 shows the construction inside the light module 2 by taking the light module 2(1) as an example. Semiconductor lasers 3(1-a), 3(1-b) and drive circuits 4(1-a), 4(1-b) for the semiconductor lasers are contained in the light module 2(1). Therein, in regard to the characters in the parentheses, the numeral indicates the number of the light module containing the semiconductor laser or the semiconductor laser drive circuit, and the characters a and b indicate for wavelengths 780 nm and 830 nm, respectively. The semiconductor laser drive circuits 4(1-a), 4(1-b) apply direct current bias current to the semiconductor lasers 3(1-a), 3(1-b), and also apply voltages having frequencies  $f(1-a)$ ,  $f(1-b)$  different from each other to the oscillators 3, respectively, to modulate light beams emitted from the semiconductor lasers 3(1-a), 3(1-b). The modulation in the present embodiment is analogue modulation using sinusoidal waves, but of course, digital modulation using rectangular waves having time intervals different from each other may be used. Each of the light beams modulated as described above is introduced into each of optical fibers 6 through each of condenser lenses 5 for each of the semiconductor lasers. Each of the light beams of the two wavelengths introduced into each of the optical fibers is introduced into an optical fiber, for

example, an irradiation optical fiber 8-1 by an optical fiber coupler 7. The two-wavelength light beams from the light modules are introduced into the irradiation optical fibers 8-1 to 8-4, respectively, and irradiated onto four different irradiation  
 5 positions on the surface of a body 9 to be inspected out of the other ends of the irradiation optical fibers. Light reflected from the body to be inspected is detected by detecting optical fibers 10-1 to 10-5 arranged at five detecting positions. An end surface of each of the optical fibers is softly in contact  
 10 with the surface of the body 9 to be inspected, that is, the optical fiber is attached to the body 9 to be inspected using, for example, a probe described in Japanese Patent Application Laid-Open No.9-149903.

FIG. 24 is a view showing an example of a geographical  
 15 arrangement of the irradiation positions 1 to 4 and the detecting positions 1 to 5 on a surface of the body 9 to be inspected. In the present embodiment, the irradiation position and the detecting position are alternatively arranged on a square lattice. Assuming that the middle position between the  
 20 irradiation position and the detecting position adjacent to each other is a measured position, number of measured positions, that is, number of measurement channels is 12 because there are 12 combinations of the irradiation position and the detecting position adjacent to each other. The arrangement of the light  
 25 irradiation positions and the detecting positions is described, for example, in Japanese Patent Application Laid-Open No.9-149903 and an article entitled "Near-infrared topographic measurement system: Imaging of absorbers localized in a scattering medium" by Yuichi Yamashita et al., Review of

Scientific Instrument, Volume 67, pages 730 - 732. It is reported, for example, in an article entitled "Intracerebral penetration of infrared light" by P.W.McCormic et al., Journal of Neurosurgery, Volume 76, pages 315 - 318 that when the  
5 interval between the irradiation position and the detecting position adjacent to each other is set to 3 cm, light detected at each of the detecting positions penetrates through the skin and the skull and has information.

From the above, by setting twelve measurement channels  
10 under the arrangement of the irradiation and the detecting positions, a cerebrum in an area of 6 cm  $\times$  6 cm can be measured as a whole. Although the present embodiment shows the case where the number of measurement channels is 12 in order to simplify the explanation, the measurement area can be easily expanded  
15 by further increasing numbers of the light irradiation positions and the light detecting positions arranged in a lattice to further increase number of measurement channels.

Referring to FIG. 1, the reflected light detected by each of the detecting optical fibers 10-1 to 10-5 is detected on the  
20 detecting position basis, that is, detected independently in the detecting optical fiber corresponding to each of the detecting positions using the five light detectors, for example, using the photo-diodes 11-1 to 11-5. The photo-diode is preferably an avalanche photo-diode which can realize high  
25 sensitive light measurement. Further, a photo-multiplier tube may be used as the light detector. After converting the light signal into an electric signal by the photo-diode, a modulated signal corresponding to both of the irradiation position and the wavelength is selectively detected by the lock-in amplifier

module 12 composed of a plurality of circuits for selectively detecting a modulated signal, for example, a plurality of lock-in amplifiers. Although in the present embodiment the lock-in amplifiers are shown as the modulated signal detecting  
 5 circuits coping with the case of analogue modulation, digital filters or digital processors for detecting the modulated signals are used in a case of using digital modulation.

FIG. 25 is a block diagram showing the construction of lock-in amplifier module of FIG. 1. Initially, explanation will  
 10 be made on modulated signal separation of the detected signal detected by the photo-diode 11-1 at the position 1 in FIG. 24. At the "detecting position 1", the light irradiated at the "light irradiation position 1", at the "light irradiation position 2", at the "light irradiation position 3" and at the  
 15 "light irradiation position 4" adjacent to the detecting position 1 can be detected, and accordingly the "measured position 4", the "measured position 6", the "measured position 7" and the "measured position 9" in FIG. 24 are positions to be measured. Here, the detected signal detected by the  
 20 photo-diode 11-1 at the "position 1" includes eight signal components having the modulation frequencies of  $f(1-a)$ ,  $f(1-b)$ ,  $f(2-a)$ ,  $f(2-b)$ ,  $f(3-a)$ ,  $f(3-b)$ ,  $f(4-a)$  and  $f(4-b)$  corresponding to the two-wavelength light each irradiated onto the "irradiation position 1", the "irradiation position 2", the  
 25 "irradiation position 3" and the "irradiation position 4". The light signals containing the eight signal components are introduced into the eight lock-in amplifiers 13-1 to 13-8 through the 8 amplifiers 14-1 to 14-8. Modulation frequency signals of  $f(1-a)$ ,  $f(1-b)$ ,  $f(2-a)$ ,  $f(2-b)$ ,  $f(3-a)$ ,  $f(3-b)$ ,

f(4-a) and f(4-b) are given to the 8 lock-in amplifiers 13-1 to 13-8 as reference signals, respectively. Therefore, the light signal components of 780 nm and 830 nm wavelengths irradiated onto the "irradiation position 1" are selectively  
5 separated by the lock-in amplifiers 13-1 and 13-2; the light signal components of 780 nm and 830 nm wavelengths irradiated onto the "irradiation position 2" are selectively separated by the lock-in amplifiers 13-3 and 13-4; the light signal components of 780 nm and 830 nm wavelengths irradiated onto the  
10 "irradiation position 3" are selectively separated by the lock-in amplifiers 13-5 and 13-6; and the light signal components of 780 nm and 830 nm wavelengths irradiated onto the "irradiation position 4" are selectively separated by the lock-in amplifiers 13-7 and 13-8.

15 In regard to the detecting signals detected by the photo-diodes 11-2 to 11-5 at the "detecting position 2", at the "detecting position 3", at the "detecting position 4" and at the "detecting position 5", respectively, the desired light signal components are similarly selectively separated to be  
20 lock-in detected. That is, the light signal detected by the photo-diode 11-2 at the "detecting position 2" is introduced into the four lock-in amplifiers 13-9 to 13-12 through the four amplifiers 14-9 to 14-12, and the light components of 780 nm and 830 nm wavelengths irradiated at the "irradiation position  
25 1" and the light components of 780 nm and 830 nm wavelengths irradiated at the "irradiation position 2" each are selectively separated to be lock-in detected; the light signal detected by the photo-diode 11-3 at the "detecting position 3" is introduced into the four lock-in amplifiers 13-13 to 13-16 through the four



amplifiers 14-13 to 14-16, and the light components of 780 nm and 830 nm wavelengths irradiated at the "irradiation position 1" and the light components of 780 nm and 830 nm wavelengths irradiated at the "irradiation position 3" each are selectively  
 5 separated to be lock-in detected; the light signal detected by the photo-diode 11-4 at the "detecting position 4" is introduced into the four lock-in amplifiers 13-14 to 13-20 through the four amplifiers 14-14 to 14-20, and the light components of 780 nm and 830 nm wavelengths irradiated at the "irradiation position  
 10 3" and the light components of 780 nm and 830 nm wavelengths irradiated at the "irradiation position 4" each are selectively separated to be lock-in detected; and the light signal detected by the photo-diode 11-5 at the "detecting position 5" is introduced into the four lock-in amplifiers 13-21 to 13-24  
 15 through the four amplifiers 14-21 to 14-24, and the light components of 780 nm and 830 nm wavelengths irradiated at the "irradiation position 2" and the light components of 780 nm and 830 nm wavelengths irradiated at the "irradiation position 4" each are selectively separated to be lock-in detected.

20 It can be understood from FIG. 24 that in the case where the detecting positions are the "detecting position 2", the detecting position 3", the "detecting position 4" and the "detecting position 5", the positions to be measured are the "measured position 1" and the measured position 3", the measured  
 25 position 2" and the "measured position 5", the measured position 10", and the "measured position 8" and the "measured position 11".

As described above, in the case where number of the wavelengths is two and number of the measured positions is

twelve, twenty-four of the lock-in amplifiers 13-1 to 13-24 in total are used in the lock-in amplifier module 12. Each of the analogue signals output from the lock-in amplifiers 13-1 to 13-24 (channel 1 to 24) is accumulated for a preset time by a sample hold circuit of the channel corresponding to the sample hold circuit module 16. After completion of the accumulation, the switch (multiplexer) 17 is sequentially switched to convert the signal accumulated in each of the sample hold circuits to a digital signal, for example, by a 12-bit analogue/digital converter (A/D converter) 18, and the converted signals in all of the channels are stored in a memory unit outside a computer 19. Of course, the converted signals may be stored in a memory unit inside the computer 19.

The channel number corresponds to the address of the memory unit with a one to one relation

In a case of not using the sample hold circuit module 16, the switch 17 is repetitively switched at high speed. The analogue signal of each channel is converted into a digital signal using the analogue/digital converter 18 every switching to be accumulated in the memory unit 20, and the digital signals acquired a preset number of times are averaged on the channel basis to be stored in the memory unit 20. This method can reduce noise of high frequency components.

Based on the data stored in the computer 19, change in the concentration of oxygenated hemoglobin and change in the concentration of deoxygenated hemoglobin associated with cerebral activity, and further change in the concentration of total hemoglobin as the total concentration of hemoglobin are calculated through the method described in, for example,

Japanese Patent Application Laid-Open No.9-19408 and in an article entitled "Spatial and temporal analysis of human moter activity using noninverse NIR topography" by Atsushi Maki et al., Medical Physics, Volume 22, pages 1997 - 2005 (1995), and  
 5 the result such as a topography image or the like is displayed on the display portion 20.

Referring to FIG. 1, the computer 19 may be a personal computer. An operating portion 22 is connected to the computer 19, and the operating portion includes a keyboard, a mouse and  
 10 so on for inputting and outputting various kinds of information and for adding and deleting data. FIG. 26 is a graph showing time variation of a measured signal 30 at a detecting position and of a predicted no-load signal 31 obtained from the measured signal. The graph is displayed on the display portion 21, and  
 15 the abscissa indicates measurement time and the ordinate indicates an amount of relative change in hemoglobin concentration, that is, the amount corresponding to change in hemoglobin concentration at a specific position in a cerebrum caused by motion of a specific position of a body (for example,  
 20 motion of a part of the body such as a finger or the like). The predicted no-load signal 31 is obtained from the measured signal 30 by fitting an arbitrary function to the measured signal 31 in the time before loading T1 and the time after applying load T3 except the signals in the time applying load (loading time)  
 25 Tt and the time until the signal returns the original value (relaxation time) T2 through the least-squares method. In the present embodiment, the processing is performed by using a secondary-order linear polynomial for the arbitrary function and by setting  $T1 = 40$  seconds,  $T2 = 30$  seconds and  $T3 = 30$

seconds.

FIG. 27 shows an example of time variations of an amount of relative change in concentrations of oxygenated hemoglobin and an amount of relative change in concentrations of deoxygenated hemoglobin at a measurement position. The graph is displayed on the display portion 21. The abscissa indicates measurement time and the ordinate indicates relative amounts of change in the concentrations. The time illustrated by the hatched area is a load applying time (a period of moving a finger of right hand). In regard to the relative amount of change shown in FIG. 26, the relative amounts of changes in oxygenated hemoglobin and in deoxygenated hemoglobin ( $H_bO_2$ ,  $H_b$ ) associated with load application is calculated based on the non-load signal 31 and the predicted non-load signal 32 through a predetermined calculation processing.

Each of FIG. 28 and FIG. 29 shows a contour image (a topography image) produced from the time variation of the relative amount of change in a concentration of oxygenated hemoglobin at each measurement position displayed in the display portion 21 when motion of left-hand or right-hand fingers of a person to be inspected is used as load, respectively. The topography image is formed by calculating an integrated value with time (an averaged value with time may be acceptable) of the signal of relative amount of change 32 in the load applying time (the hatched period in FIG. 27) by the processing portion 19, and linearly interpolating between the measured positions in the X-axis direction and the Y-axis direction. As the topography image, a monochrome gray-scale image or a color identifying image may be acceptable instead of the contour image

shown in FIG. 28 and FIG. 29. It can be understood from FIG. 28 and FIG. 29 that the oxygenated hemoglobin concentration is clearly increased at a specific position when right-hand finger is moved.

5 By displaying such information of spatial distribution as an image, recognition of the measured result can be made speedy and easy. Further, although the images shown in FIG. 28 and FIG. 29 are formed using the time-integrated values of the relative amount of change in concentration during the load apply  
10 time period, a similar topography image can be formed using relative amounts of change in oxygenated hemoglobin concentration at the measured positions every measuring time performed at a time. By displaying the plurality of formed topography images in order of measured time or as a moving  
15 picture, the time variation of the relative amount of change in the oxygenated hemoglobin concentration can be understood.

Further, by calculating a self-correlation function of the time variation of the relative amount of change in oxygenated hemoglobin concentration at an arbitrary one  
20 measured position and a mutual-correlation function of the time variation of the relative amount of change in oxygenated hemoglobin concentration at one and the other measured positions, a topography image for each position can be also formed from the correlation functions. Since the correlation  
25 function at each position is a function defined by shifting time by  $\tau$ , a state of propagation of change in a dynamic blood state can be visualized by forming photography images from the values of the correlation functions shifting by the same time of  $\tau$  and displaying the photography images in order of  $\tau$  or as a moving

picture. Although the description here is made on the relative amount of change in oxygenated hemoglobin concentration as the typical example, the relative amount of change in deoxygenated hemoglobin concentration and the relative amount of change in the total hemoglobin concentration calculated as the sum of the relative amounts of change in oxygenated and deoxygenated hemoglobin concentrations can be similarly formed in the topography images.

FIG. 30 shows an example of a display superposing a topography image 34 formed through the method described above on a cerebrum surface image 35 of a person to be inspected. Since the topography image 34 is change in a dynamic blood state of a cerebrum changing in association with change in a biological function, it is preferable that the topography image is displayed by superposing on the cerebrum surface image. The cerebrum surface image 35 is displayed by being measured by a three-dimensional MRI or a three-dimensional X-ray CT. The topography image 34 is a topography image which is formed by converting the coordinate system so that the coordinates of the measured positions are placed on the surface of the cerebrum, and then interpolating the values between the measured positions. When the formed topography image 34 is displayed by superposing on the cerebral surface image 35, the color of the superposed topography image 34 is made translucent so that the cerebral surface image under the topography image 34 can be seen.

FIG. 2 is a flowchart showing an example of processing flow in accordance with the present invention for measuring a body to be inspected using the optical measurement system shown

in FIG. 1. Operation of the optical measurement system is sequentially performed while an operator is looking at the windows, shown in FIG. 3 to FIG. 22, displayed on a window display screen of the display portion 21.

5       As the operating system of the system is booted, an initial window for selecting main menu shown in FIG. 3 is displayed (S1). Referring to FIG. 3, the processing proceeds to measurement processing when the button 301 is selected, the processing proceeds to data analysis when the button 302 is  
10       selected and the program is ended when the button 303 is selected.

Assuming now that the button 301 is selected, the initial window shown in FIG. 3 disappears, and the processing proceeds to the measurement processing to display a window for inputting  
15       conditions shown in Fig. 4 is displayed in the middle of the display screen of the display portion 21 (S2). In regard to FIG. 4, meaning and function of each part are as follows.

401: A bar for inputting a title. In detail, a name of inspection to be performed is input.

20       402: A part for displaying data and time, data and time as displaying the window is displayed by default (automatically displayed numerals or characters).

403: A part for inputting a kind of stimulation (for example, finger motion, writing, speaking, giving medication  
25       and so on). A list display button (an inverted delta symbol button) is pushed and then desired items are selected from pre-registered kinds in the list box. The selected kinds are displayed by changing the back color or with reversed characters. The data can be added, deleted and replaced.

404: A kind of item selected in the stimulation input part can be deleted by this button.

405: A part for selecting a measurement mode. The measurement mode is determined by number of measuring channels and number of surfaces to be measured. For example, in a case where number of measurement channels is 1 and number of surfaces to be measured is 2, it is assumed that measurement mode 1 is selected.

406: A part for freely writing memorandum.

10 407: A part for inputting name of a person to be inspected.

408: A part for inputting age of a person to be inspected.

409: A part for inputting sex of a person to be inspected.

410: A part for inputting a kind of a person to be inspected, that is, a patient or a healthy parson.

15 411: A setting ending button.

412: A button for returning to the initial window.

After inputting and setting the above conditions, by pushing the button 412, the window for inputting conditions disappears and a window for displaying gain adjusting underway shown in FIG. 5 is displayed in the middle of the screen (S3). This expresses that the measurement system is under automatic gain adjusting, and after completion of the adjustment the window for displaying gain adjusting underway disappears and a window for displaying measured positions is displayed in the middle of the display screen (S4). Essentially after now, this window is always displayed at a position in the screen of the display portion 21. By always displaying the window for displaying measured positions, it is possible to easily and speedily understand the correspondence between the many



measured signals and the actual measured positions. There, the irradiation optical fibers 8-1 to 8-4 and the detecting optical fibers 10-1 to 10-5 shown in FIG. 1 are generally fixed in a helmet to be put on by the person to be inspected. Therefore, if measuring channel numbers are indicated on the helmet to make the positional relationship between the number shown by the reference character 602 in FIG. 6, recognition of the operator is further assisted.

Referring to FIG. 6, the reference character 601 is a part for displaying the selected measuring mode, the displayed window for displaying measured positions corresponds to the measuring mode. The reference character 602 is a part for displaying number of measuring channels of the measured plane. The reference character 603 indicates the setting positions of the irradiation and the detecting optical fibers, that is, the irradiation positions and the detecting positions. The reference character 604 indicates the measuring channel numbers, and the measuring channel number is displayed in green color when the automatic gain adjustment of the measuring channel is well performed.

When there exists at least one measuring channel which is failed in the gain adjustment, the measuring channel number of the measuring channel is displayed in red color. Further, in this case, a window for display abnormality shown in FIG. 7 is displayed near the window for displaying measured positions shown in Fig. 6 (S5). The case where the gain adjustment is failed means that there is possibly a problem in a measured position in the right-hand side or the left-hand side or the upper side or the down side of the channel displayed in red color.

Since it is considered that there is a problem in setting of the optical fiber when the red-colored display appears, the optical fiber is required to be reset. Therefore, after resetting the optical fiber, the reference character 701 in FIG. 7 is used when the measurement is aborted by returning to the window of FIG. 3 or FIG. 4. When the button 702 of FIG. 7 is pushed, the window for display abnormality is deleted and the window for displaying gain adjusting underway is displayed to perform the automatic gain adjustment again. When there remains still any abnormality after adjusting gain, the window for displaying gain adjusting underway shown in FIG. 5 is deleted, and the abnormal measuring channel in the window for displaying measured positions shown in FIG. 6 is displayed in red color, and the window for displaying abnormality shown in FIG. 7 is displayed near the window for displaying measured positions shown in FIG. 6. When no abnormality occurs, the window for displaying gain adjusting underway shown in FIG. 5 is deleted, and all the measuring channels in the window for displaying measured positions shown in FIG. 6 are changed to green color, and a window for forming a file shown in FIG. 8 is displayed.

In FIG. 7, the reference character 703 is a button which is pushed when the abnormality is neglected. When the button is pushed, the window for forming a file is displayed (S6) by neglecting the abnormal measuring channel in the window for displaying measured positions shown in FIG. 6 (remaining the red colored display as it is). The window for forming a file shown in FIG. 8 is displayed in the middle of the display screen regardless of presence and absence of abnormality, and the position of the window for displaying measured positions shown

in FIG. 6 is moved to a lower left position in the display screen as the window for forming a file shown in FIG. 8 is displayed. By this display method, the operator can always watch the condition to be input.

5           In FIG. 8, meaning and function of each part are as follows.

801: A part for inputting a file name.

802: A part for displaying a list of all files existing in a hierarchy which is selected by the button 804. For example,  
10   data names of measurement previously performed are displayed in this part.

803: A part for displaying the present path.

804: A part for displaying a directory list (hierarchy list).

15           805: A button for giving permission to proceed to measurement process.

806: A pushed button for canceling and returning to the window for inputting conditions of FIG. 4. When the button is pushed, the window for forming a file shown in FIG. 8 and the  
20   window for displaying measured positions shown in FIG. 6 are deleted, and the window for inputting conditions shown in FIG. 4 is displayed.

807: A button for displaying the window for creating directory, and the button is used when creating a new directory.  
25   When the button is pushed, the window for creating directory is displayed superposing on the window for forming a file shown in FIG. 8 in a slightly shifting state. At that time, the window for creating directory shown in FIG. 9 can not be operated.

808: A button for performing specifying a drive.

When the button 807 is pushed, the window for creating directory shown in FIG. 9 is displayed (S7). Referring to FIG. 9, the reference character 901 is a part for inputting name of a directory to be created, the reference character 902 is a button for completing directory creation, and the reference character 903 is a cancel button. When any one of the buttons is pushed, the window for creating directory shown in Fig. 9 is deleted and the processing is returned to the window for forming a file shown in FIG. 8.

Referring to FIG. 8, when the button 805 is pushed, the window for forming a file shown in FIG. 8 is deleted, and a measurement window shown in FIG. 10 is displayed an upper left portion of the display screen (S8), and a window or windows for displaying measurement data time sequence shown in FIG. 14 is or are displayed in a large portion in the right side of the display screen (S11). FIG. 8 is used for controlling execution of measurement. In regard to FIG. 10, meaning and function of each part are as follows.

1001: A button for selecting Info. When Info is selected, a window for selecting Condition or Tuneup as a sub-menu, as shown in FIG. 11. When Condition in sub-menu of FIG. 11 is selected, the window for inputting condition similar to FIG. 4 is displayed (S9). This is for checking the present status or inputting an additional condition. When Tuneup in the sub-menu of FIG. 11 is selected, a window for inputting measuring condition and display condition shown in FIG. 12 is displayed (S12). When the cancel button is pushed in the step 9 or step 10, the window for inputting condition similar to FIG. 4 or the window for inputting measuring condition and display

condition shown in FIG. 12 is deleted, and the processing is returned to the measurement window of FIG. 10.

1002: When Option is selected by the button for selecting Option, A sub-menu window shown in FIG. 13 is displayed. Here,  
 5 graph display conditions for measurement underway, and conditions of a data backup interval and signals output from the other measurement instruments to be described later are input, but there is no need to input every time because there is a learning function to automatically reflecting values which  
 10 are set at the preceding measurement.

1003: A part for specifying and displaying a data acquisition time interval.

1004: A part for displaying number of data acquisition times (number of sampling times).

15 1005: A part for displaying a measuring elapsing time.

1006: A part for displaying the next measurement state.

Run : measuring underway

Completion : normal completion of measurement

20 Overrun : abnormal completion of measurement due to overflow of A/D converter

Stop : abnormal completion of measurement due to the other cause

File error : error in measurement file writing

Backup file error : error in backup file writing

25 1007: A button for starting measurement. When the button is pushed, measurement is started and measurement data time sequence signal graph is displayed in each axis in FIG. 14 (S11). The displayed graph expresses a change ratio.

1008: A button for completing data acquisition.

1009: A button for completing measurement and inspection.

1010: A part for displaying an elapsing time after pushing Mark button 1011. By this part, there is an advantage in that a stimulating time period can be managed without using any  
5 stopwatch.

1011: The Mark button which is for inserting a mark of a vertical line in the graph of FIG. 14 during measurement. This mark is usually input at starting and at completing stimulation as a reference for data analysis, but the mark may be arbitrarily  
10 input when an event requiring to record time occurs during measurement. When a mark input signal is supplied from an external device, a mark is displayed in the drawing of figure 14 without pushing the button. Moreover, a sound may be generated When the mark input signal is supplied.

15 In the window for inputting measuring condition and display condition shown in FIG. 12, a measurement condition corresponding to a selected measurement mode is displayed. The measurement condition expresses correspondence to a measuring channel (measuring position), a channel of A/D converter, a  
20 wavelength, a signal amplification and so on. Further, specifying of a channel to measure and specifying a channel to display may be possible. Furthermore, it is possible to instruct to input another signal into a vacant channel. In regard to FIG. 12, meaning and function of each part are as follows.

25 1201: There are tables showing the measurement conditions and the display conditions for each wavelength using in the selected mode, and a table in regard to a wavelength to be displayed is selected using this tab.

1202: A part for specifying requirement of displaying a

graph to display the graph. The word True in the column means displaying the graph, and the word False means not displaying the graph. By pre-selecting graphs not required to be display for individual channels (by clicking a box in the Visible column, 5 the selection is performed to change the back color or to be inversely displayed), and then by specifying a False button of 1212, the selected measurement channel is turned from True to False.

1203: A part for displaying a gain of the lock-in 10 amplifier.

1204: A part for displaying a dynamic range of the A/D converter. In the columns of the parts 1203 and 1204, the values determined by the automatic gain adjustment are displayed.

1205: A part for displaying wavelength.

15 1206: A part for displaying a kind of signal. The word Optical means optical measurement. For example, in a case where a brain wave signal is measured at a time using an additional channel (the addition can be specified in the part 1208), the operator inputs EEG. The signals other than Optical can be 20 separately processed during data analysis.

1207: A part for displaying a channel number of measurement.

1208: A part for specifying and displaying effectiveness (True) and ineffectiveness (False) of the channel number of the 25 A/D converter. The specifying method is similar to the case of the part 1202. When False is selected in a channel, measurement in the specified channel is not performed.

1209: A window for inputting a character string or a number string in a position selected in the parts 1202 to 1208.

1210: A part for changing the dynamic range of the A/D converter. It become effective when the part 1204 is selected.

1211: A part for changing a gain of the lock-in amplifier. It become effective when the part 1203 is selected.

5        1212: A part for switching True and False in the columns 1202 and 1208.

1213: A part for selecting a displayed measurement mode. The word Each means that displayed tables are displayed by a plurality of tables for each wavelength, and the word All means  
10        that all the measuring channels are displayed by one table.

1214: A button for completing setting.

1215: A button for canceling setting.

According to the window of FIG. 12, checking and setting change can be easily performed because the monitor of the  
15        measurement conditions (1203 to 1208) and the conditions of graph display (1202) are shown on the single window. Further, a signal of another measurement instrument (apparatus) can be acquired using this window. Furthermore, the window of FIG. 12 is only one window that the operator inputs used conditions by  
20        selecting necessity of measuring input signals.

In a sub-menu window of Option in the measurement window of FIG. 10, the following windows is displayed depending on which is selected. However, displays of Trigger Pulse and External Trigger to be selected are omitted in FIG. 13.

25        Graph        : A window for inputting the display conditions of graph of FIG. 14 (FIG. 15)

Backup        : A window for inputting a file backup condition (FIG. 16)

Other CH       : A window for input setting of the other



measurement equipment output signal (FIG. 17)

Trigger Pulse : A window for setting a rectangular wave output signal (FIG. 18)

External Trigger : A window for setting an external input  
5 trigger synchronous measurement condition (FIG. 20)

Measurement Parameter : A window for setting a measured data acquiring condition (FIG. 21)

Prescan : A window for checking a measured signal (FIG.  
22)

10 Position : A window for displaying measured positions (FIG. 6) (returning to the step S6)

In regard to FIG. 15 to 18 and 20 to 22, meaning and function of each part are as follows.

FIG. 15 (the window for inputting the display conditions  
15 of graph of FIG. 14) (S12)

1) A range of the X-axis is input. In order to input the range, there are two input methods, that is, one is a method of inputting a magnification performed in 1501, and the other is a method of inputting a displayed time performed in 1503.

20 1501: A button for selecting a display magnification inputting of the X-axis of graph.

1502: A part for inputting a display magnification of the X-axis of graph by a percentage. For example, in a case where the time period of 3600 seconds is displayed when the  
25 magnification is 100 %, the displayed time period becomes within a range of 360 seconds if the magnification is changed to 1000 %. In this case, when the time exceeds 360 seconds, the window is scrolled to the left-hand side. In detail, assuming data of 362 seconds is acquired, the displayed range of the X-axis of the

graph of FIG. 14 is from 2 seconds to 362 seconds.

1503: A button for selecting the displayed time inputting of the X-axis of the graph. When this button is selected, the button 1501 is automatically changed to not selected. The button  
5 1501 and the button are mutually exclusive.

1504: A part for inputting a displayed time period of the X-axis of the graph.

1505: A part for displaying number of data kinds acquired within a displayed time period specified in the part 1504.

10 2) A range of the Y-axis is input.

1506: A part for selecting a display magnification inputting of the Y-axis of graph. The way of thinking is similar to that of the case of selecting a display magnification inputting of the X-axis of graph.

15 3) The format of graph display of FIG. 14 is selected.

1507: A button for selecting displaying all the channels (all the channels selected to display in FIG. 12) in order of the measured channel. When this button is selected, the windows shown in FIG. 14, number of which is equal to number of the  
20 wavelengths used in each measurement channel in number (two wavelengths in this embodiment), are displayed so as to overlap with each other. In that case, the first window shows signals of the first wavelength in order of the measured channel, and the second window shows signals of the second wavelength in  
25 order of the measured channel. If the setting is particularly not made, Together is selected.

1509: A button for displaying all the channels within a single window.

1509: A button for separately displaying within a window

for each channel. Further, there are two kinds of display methods as follows.

Title: Graphs are displayed by arranging in a matrix-shape.

5 Cascade: Graphs are displayed by superposing on another.

1510: A button for displaying only one specified channel (the channel displayed in FIG. 12 can be selected).

1511: A part for forcing not displaying the graphs.

1512: A part for completing the setting. By completing  
10 the setting, the window display is returned to the window display of FIG. 10.

1513: A part for canceling. In the case of canceling, the window display is also returned to the window display of FIG. 10.

15 FIG. 16 (the window for inputting a file backup condition) (S13)

This window is for setting the condition of function of backup data during measurement at any time by assuming a case of a power outage during measuring or a case where a file  
20 specified by the window for forming a file of FIG. 8 is damaged due to some causes.

1601: A part for specifying whether or not backup is necessary.

1602: A part for inputting a backup time interval.

25 1603: A part for inputting a backup file name by full-pass.

1604: A part for referring to a directory and a file. The window for forming a file of FIG. 8 is displayed, and the specified file name is entered to Backup File Name area.

1605: A button for completing the setting. By completing the setting, the window display is returned to the window display of FIG. 10.

1606: A button for canceling. In the case of canceling,  
5 the window display is also returned to the window display of FIG. 10.

FIG. 17 (The window for input setting of the other measurement equipment output signal) (S14)

By this window, a signal output from another measurement  
10 instrument is acquired from data of a vacant A/D converter channel. A channel number of the A/D converter used at acquiring the data, a name of kind of the signal (EEG and so on) and a dynamic range of the A/D converter are selected.

1701: A part for displaying a channel number of a vacant  
15 A/D converter used for inputting. The vacant A/D converter having a least channel number is automatically allocated.

1702: A part for inputting a kind name of signal.

1703: A part for selecting a dynamic range of an A/D converter of another input.

20 1704: A button for completing the setting. By completing the setting, the window display is returned to the window display of FIG. 10.

1705: A button for canceling. In the case of canceling, the window display is also returned to the window display of  
25 FIG. 10.

FIG.18 (The window for setting a rectangular wave output signal (S15))

A rectangular wave voltage signal is periodically output from the present optical measurement system. By inputting this

signal into the other measurement instruments (a brain wave meter and so on), the measuring time can be strictly set in agreement between the instruments. The rectangular wave signal is output from, for example, a serial board of a personal  
5 computer.

There are three kinds of the output rectangular wave signals, as shown in FIG. 19. The first kind is a rectangular wave signal which is output only at starting of measurement. The second kind is a rectangular wave signal which is  
10 periodically output until the measurement is completed. The third kind is a rectangular wave signal which is output in synchronism with pushing of the mark button of FIG. 10. The condition of these three kinds of rectangular wave signals can be set by the window of FIG. 18.

15 1801: A part for selecting whether or not the rectangular wave output is necessary.

1802: A part for selecting a terminal to output the rectangular wave signal.

1803: A part for inputting a time width of the first kind  
20 of rectangular wave signal (refer to A of FIG. 19).

1804: A part for inputting number of repetitive times of the first kind of rectangular wave signal (refer to B of FIG. 19).

1805: A part for inputting number of repetitive times of  
25 the second kind of rectangular wave signal (refer to C of FIG. 19).

1806: A part for inputting a time width of the second kind of rectangular wave signal (refer to D of FIG. 19).

1807: A part for inputting a time width of the third kind

of rectangular wave signal (refer to E of FIG. 19).

1808: A button for completing the setting. By completing the setting, the window display is returned to the window display of FIG. 10.

5        1809: A button for canceling. In the case of canceling, the window display is also returned to the window display of FIG. 10.

FIG. 20 (The window for setting an external input trigger synchronous measurement condition) (S16)

10        This window is a window which is used when measurement is performed in synchronism with a trigger signal from the external. By performing synchronous measurement, the time is completely in synchronism with the other measurement instrument and a stimulation apparatus.

15        2001: A part for specifying whether or not the external input trigger synchronous measurement is necessary.

2002: A part for inputting a channel number of the A/D converter used for the external input trigger signal.

20        2003: A part for inputting a measuring time to each trigger signal.

2004: A part for inputting a threshold value of a voltage value which is recognized as the trigger signal.

25        2005: A button for completing the setting. By completing the setting, the window display is returned to the window display of FIG. 10.

2006: A button for canceling. In the case of canceling, the window display is also returned to the window display of FIG. 10.

FIG. 21 (the window for setting a measured data acquiring

condition) (S17)

By this window, a channel operating frequency of the A/D converter (Burst Rate), a sampling frequency per one channel of the A/D converter (Conversion Rate), an average number of adding  
 5 times of acquired data (number of Samples), an adding time of acquired data (Acquisition Time), a data acquisition time interval (Sampling Period: the same as the part 1003 of FIG. 10) and a total measuring time can be set.

2101: A part for displaying and inputting Burst Rate.

10 2102: A part for displaying and inputting Conversion Rate.

2103: A part for displaying and inputting number of samples acquiring one sampling.

2104: A part for displaying a data acquisition time.

15 2105: A part for displaying and inputting a data acquisition time interval.

2106: A part for displaying and inputting a measurement time.

2107: A button for completing the setting. By completing  
 20 the setting, the window display is returned to the window display of FIG. 10.

2108: A button for canceling. In the case of canceling, the window display is also returned to the window display of FIG. 10.

25 FIG. 22 (The window for checking a measured signal) (S18)

This window is used for that the operator checks the state of signals by performing pre-measurement in prior to starting the actual measurement, if necessary. A value of signal displayed in the graph is expressed by a voltage value.

2201: A part for displaying a data acquisition time interval.

2202: A part for displaying number of data acquisition times (number of sampling times).

5        2203: A part for displaying a measuring elapsing time.

2204: A part for displaying a measuring state (refer to FIG. 10).

2205: A part for specifying a magnification of the X-axis of the graph (refer to FIG. 15).

10       2206: A part for displaying the result of pre-measurement by numerical values for each channel.

2207: A button for starting of checking output signals. When this button is pushed, the measured signals are displayed in a single window or a plurality of windows shown in FIG. 14  
15       corresponding to the form of the graph set by the window shown in FIG. 15.

2208: A button for aborting measurement.

2209: A button for completing the pre-measurement. By pushing this button, the display window is returned to the  
20       display window of FIG. 10.

By the embodiment described above, an operator, even if not skilled, can perform input work speedily and without error. Further, there are provided the option functions which can be set by an operator.

25       According to the present invention, it is possible to provide an optical measurement system and an optical measurement method which is suitable for optically measuring a body to be inspected and easily obtaining an image of a desired item based on information obtained by the measurement.



Further, according to the present invention, an operator, even if not skilled, can perform input work speedily and without error. Accordingly, the operator can perform the optical measurement operation even if he is not understand the operating  
5 manual very well.

Furthermore, according to the present invention, it is possible to understand a state of change in a body to be inspected, for example, an activation state of cerebral oxygen metabolism with high accuracy.

What is claimed is:

1. An optical measurement system comprising a plurality of light irradiation portions, light from said light irradiation portions being irradiated onto a body to be inspected; and a  
5 plurality of detecting portions for detecting light from said body to be inspected, which further comprises:

a display portion for displaying box-shaped pictures for indicating positions of said irradiation positions or said detecting portions;

- 10 a display portion for displaying box-shaped pictures for indicating measurement positions located between said irradiation positions and said detecting portions; and

a function to detect that either of said irradiation position or said detecting portion does not have a function of  
15 irradiation or detection and to change the box-shaped picture indicating one of said measurement positions corresponding to said irradiation position and said detecting position.

2. An optical measurement method comprising:

20 a process for indicating an irradiation position and a light detecting position;

a process for indicating a measurement position and a states of allocating number to said measurement position; and

a process for disposing said processes in a screen of a  
25 display portion.

3. An optical measurement system comprising on a screen:

a specifying portion for specifying a selected mode;

a display portion for displaying number of measurement

points; a display portion for indicating a light irradiation position and a light detecting position;

a measurement position display portion composed of portions for displaying a measurement position and a states of allocating number to said measurement position;

a measurement display portion for displaying measuring time sequence data; a portion for setting a condition of acquiring data;

a portion for displaying a status of acquiring said data; an instruction portion for instructing control of measurement; and

a mark instruction portion for marking a mark at a position on said measurement instruction portion.

4. An optical measurement system according to claim 3, wherein said portion for setting a condition of acquiring data comprises a portion for specifying and displaying a time interval of acquiring data by a light signal from a body to be inspected; a display portion for indicating number of acquiring said data; and a display portion for indicating an elapsing time of measuring said data.

5. An optical measurement system according to claim 3, wherein said instruction portion for instructing control of measurement comprises a portion for instructing initiating of measurement; a portion for instructing completing of acquiring said data; and a portion for instructing completing of measurement inspection.

6. An optical measurement system according to claim 3,  
wherein said measurement display portion is displayed largely  
and arranged so as to be not overlapped with said measurement  
position display portion, said portion for setting a condition  
5 of acquiring data, said portion for displaying a status of  
acquiring said data, said instruction portion for instructing  
control of measurement and said mark instruction portion for  
marking a mark at a position on said measurement instruction  
portion.

10

7. An optical measurement system comprising:  
an instructing portion for specifying a selected mode;  
a display portion for displaying number of measurement  
points;

15 a display portion for indicating a light irradiation  
position and a light detecting position;

a measurement position display portion composed of  
portions for displaying a measurement position and a states of  
allocating number to said measurement position; and

20 a display portion for indicating a period during  
adjusting gain.

8. An optical measurement system comprising on a screen:  
an instructing portion for specifying a selected mode;  
25 a display portion for displaying number of measurement  
points;

a display portion for indicating a light irradiation  
position and a light detecting position;

a measurement position display portion composed of

portions for displaying a measurement position and a states of allocating number to said measurement position; and  
 an abnormality displaying portion.

5 9. An optical measurement system according to claim 8,  
 wherein said abnormality displaying portion comprises an  
 instruction portion for completing an operation under  
 progressing; an instruction portion for instructing gain  
 adjustment again; and an instruction portion for instructing  
 10 to continue the operation by neglecting occurrence of an  
 abnormality.

10. An optical measurement system according to claim 8,  
 wherein said measurement position display portion is arranged  
 15 in a central portion of said screen.

11. An optical measurement system comprising:  
 a specifying portion for specifying a selected mode;  
 a display portion for displaying number of measuring  
 20 times of measurement points;  
 a display portion for indicating a light irradiation  
 position and a light detecting position;  
 a measurement position display portion composed of  
 portions for displaying a measurement position and a states of  
 25 allocating number to said measurement position;  
 a measurement display portion for displaying measuring  
 time sequence data; a portion for setting a condition of  
 acquiring data;  
 a portion for displaying a status of acquiring said data;

an instruction portion for instructing control of measurement; a mark instruction portion for marking a mark at a position on said measurement instruction portion; and

a tentative measurement instruction display portion by  
5 actual signals.

12. An optical measurement system according to claim 11,  
wherein said tentative measurement instruction display portion  
comprises at least an instruction portion for instructing a  
10 magnification of a graph.

13. An optical measurement system comprising:  
a portion for setting a condition of acquiring data;  
a portion for displaying a status of acquiring said data;  
15 an instruction portion for instructing control of  
measurement;

a mark instruction portion for marking a mark at a  
position on said measurement instruction portion; and  
a display condition input portion.

20

14. An optical measurement system according to claim 13,  
wherein said display condition input portion comprises a  
setting portion for setting a display magnification and a  
display time.

25

15. An optical measurement method comprising:  
a process for setting measurement input conditions  
through a process to instruct an optical measurement mode;  
a process to register a condition of a body to be

inspected; and

a process to set a condition of stimulation.

16. An optical measurement method comprising:

5 an initial display process for selectively instructing any one of selection of optical measurement, analysis of said optical measurement result and completion of a program;

a process for inputting items of condition including a measurement mode; a process for displaying a state expressing  
10 relationship among light irradiation positions and light detection positions and measurement positions so as to meet said mode;

a process for instructing to form a file for storing said optical measurement result;

15 a process for instructing a measurement condition to detect light signals from the inside of a body to be inspected which is irradiated by a multi-wavelength multi-channel; and

a process for displaying said signals for each channel detected according to said instructing results.

20

17. An optical measurement method comprising:

a process for specifying a selected mode;

a process for displaying number of measuring times of measurement points; a process for indicating a light  
25 irradiation position and a light detecting position;

a process for displaying a measurement position and a states of allocating number to said measurement position;

a process for displaying measuring time sequence data; a process for setting a condition of acquiring data;

a process for displaying a status of acquiring said data;  
 a process for instructing control of measurement; and  
 a process for instructing a mark marking at a position  
 on said measurement instruction portion.

5

18. An optical measurement method comprising:

a process for specifying a selected mode;

a process for displaying number of measuring times of  
 measurement points; a process for indicating a light  
 irradiation position and a light detecting position;

a process for displaying a measurement position and a  
 states of allocating number to said measurement position; and  
 a process for indicating a period during adjusting gain.

10

19. An optical measurement method comprising:

a process for specifying a selected mode;

a process for displaying number of measuring times of  
 measurement points;

a process for indicating a light irradiation position and

15

a light detecting position;

a process for displaying a measurement position and a  
 states of allocating number to said measurement position;

a process for displaying measuring time sequence data;

a process for setting a condition of acquiring data;

20

a process for displaying a status of acquiring said data;

an process for instructing control of measurement;

a process for instructing a mark marking at a position  
 on said measurement instruction portion; and

a process for instructing tentative measurement by an

25



[illegible]

## ABSTRACT OF THE DISCLOSURE

In order to provided an optical measurement system and an optical measurement method which is suitable for optically measuring a body to be inspected and easily obtaining an image of a desired item based on information obtained by the measurement, an optical measurement method comprising an initial display process for selectively instructing any one of selection of optical measurement, analysis of said optical measurement result and completion of a program (S1); a process for inputting items of condition including a measurement mode (S2); a process for displaying a light irradiation position and a light detection position and a state expressing measurement position relationship together with said mode (S4); a process for instructing to form a file for storing said optical measurement result; a process for instructing a measurement condition to detect light signals from the inside of a body to be inspected which is irradiated by a multi-wavelength multi-channel (S10); and a process for displaying said signals for each channel detected according to said instructed result (S11).

FIG. 1

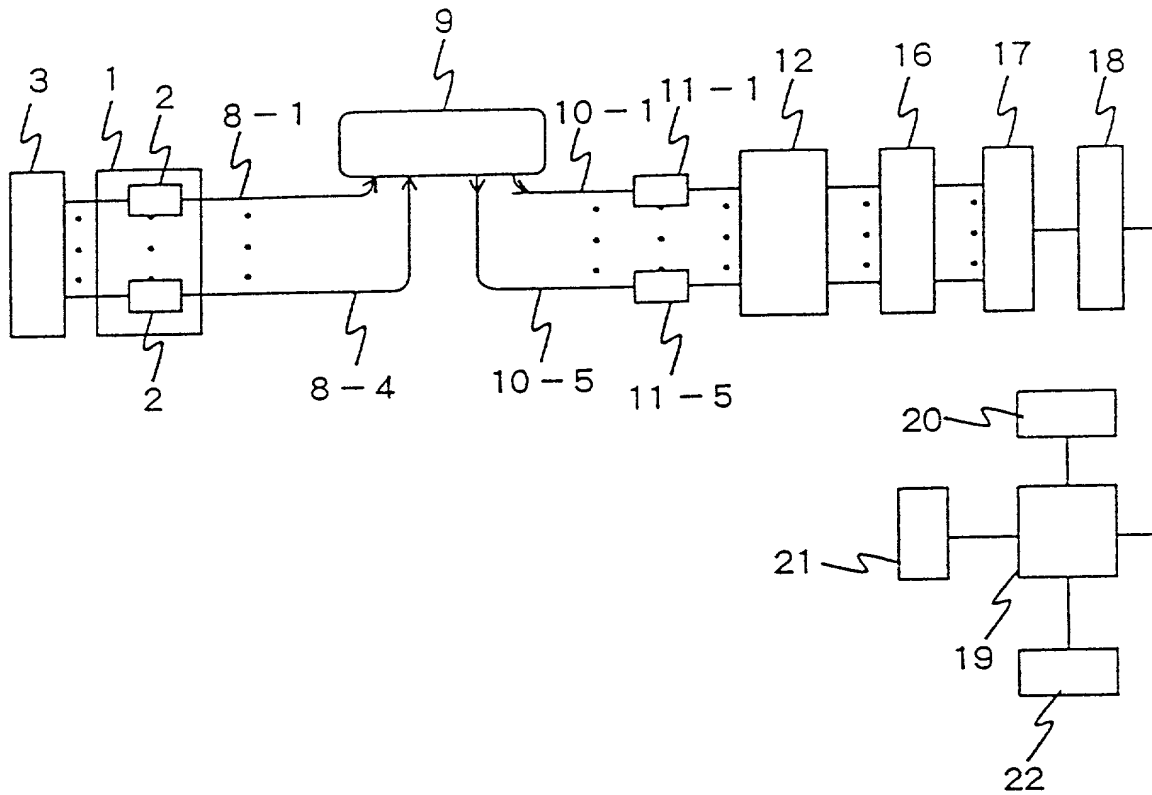


FIG. 2

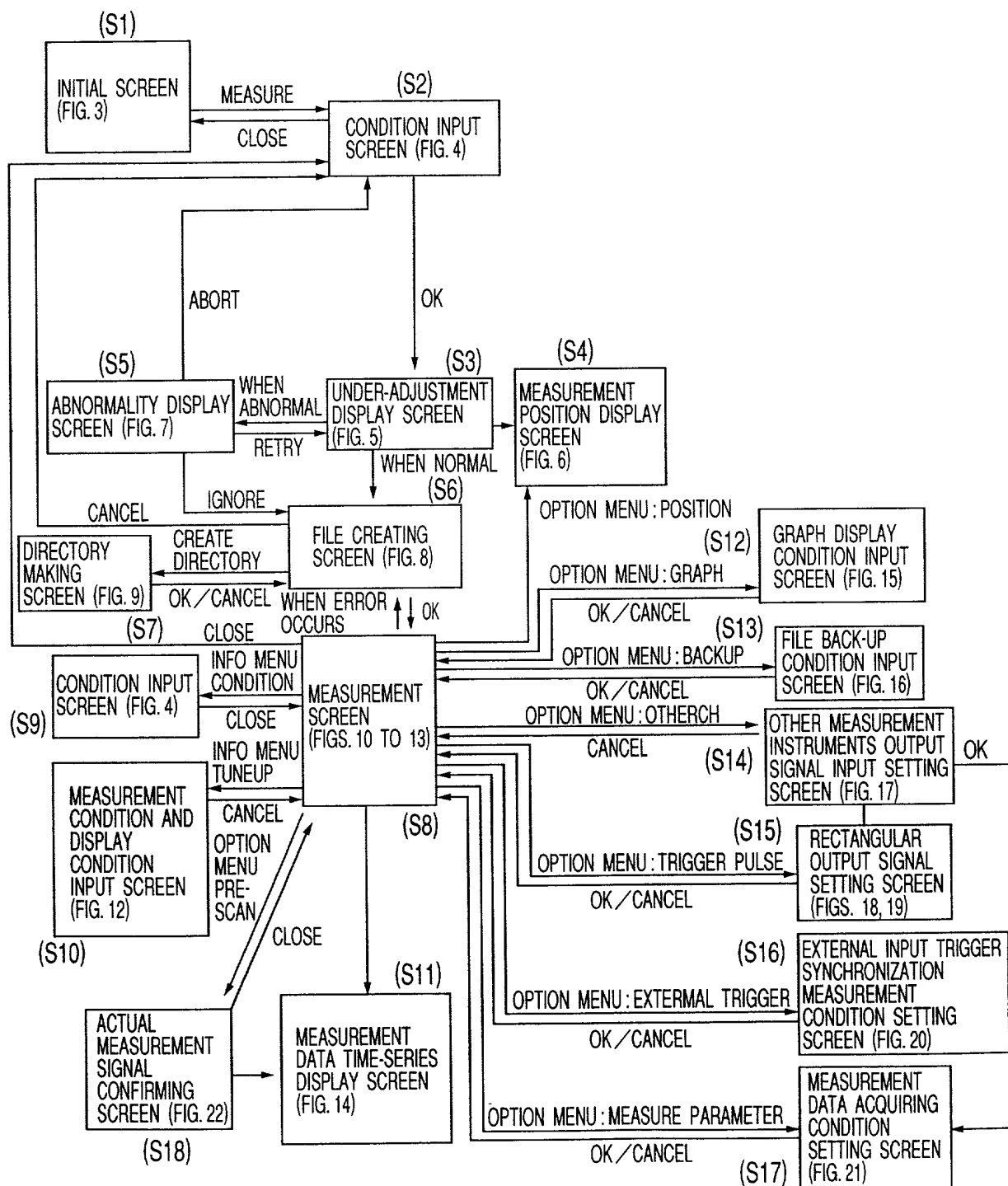


FIG. 3

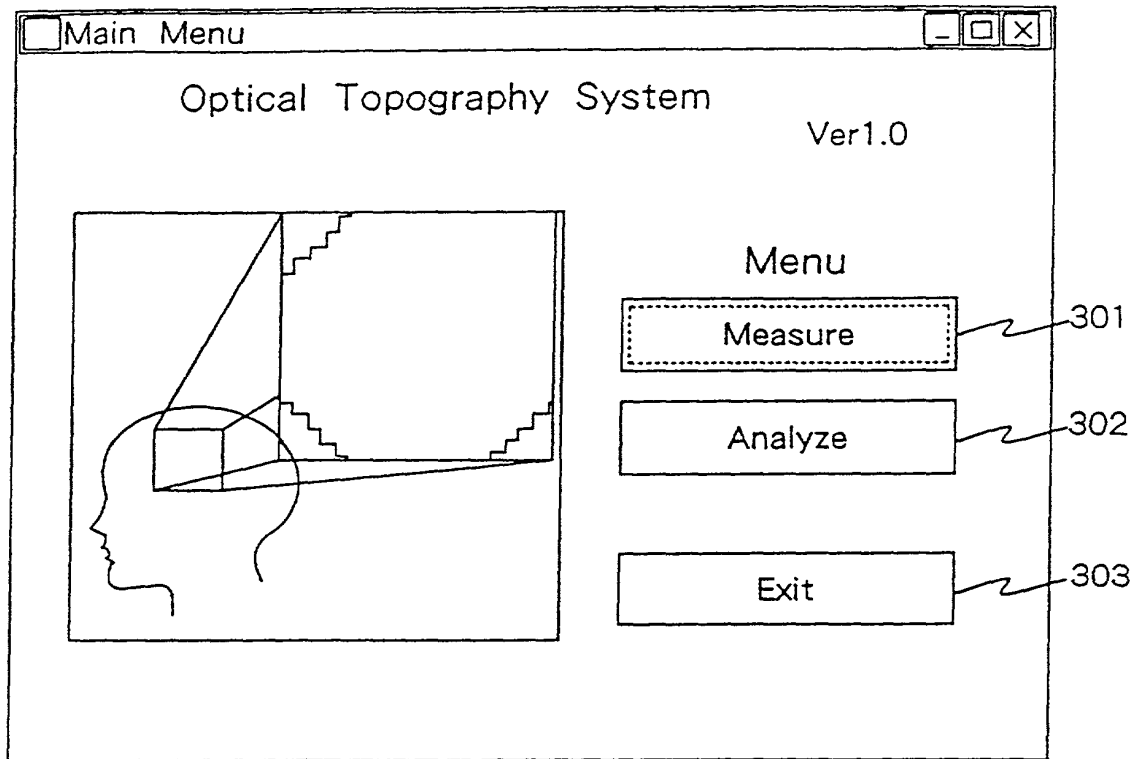


FIG. 4

Condition

Title :

Date : 01/12/98 10:54:44

Stimulation :  ☐ Remove

Measure Mode: Model (12points\*2) ☐

Memo :

Subject

Name:

Age:

☒ Male ☐ Female

☒ Healthy Volunteer ☐ Patient

OK Close

FIG. 5

Information

Adjusting Gain. Wait a minute.

FIG. 6

Position — □ ×

Face1

Label Mode2 601

No of Measure CH : 24 602

<input checked="" type="checkbox"/>	1	<input checked="" type="checkbox"/>	2	<input checked="" type="checkbox"/>	3	<input checked="" type="checkbox"/> 603
4		5		6		7 604
<input checked="" type="checkbox"/>	8	<input checked="" type="checkbox"/>	9	<input checked="" type="checkbox"/>	10	<input checked="" type="checkbox"/>
11		12		13		14
<input checked="" type="checkbox"/>	15	<input checked="" type="checkbox"/>	16	<input checked="" type="checkbox"/>	17	<input checked="" type="checkbox"/>
18		19		20		21
<input checked="" type="checkbox"/>	22	<input checked="" type="checkbox"/>	23	<input checked="" type="checkbox"/>	24	<input checked="" type="checkbox"/>

Close 605

FIG. 7

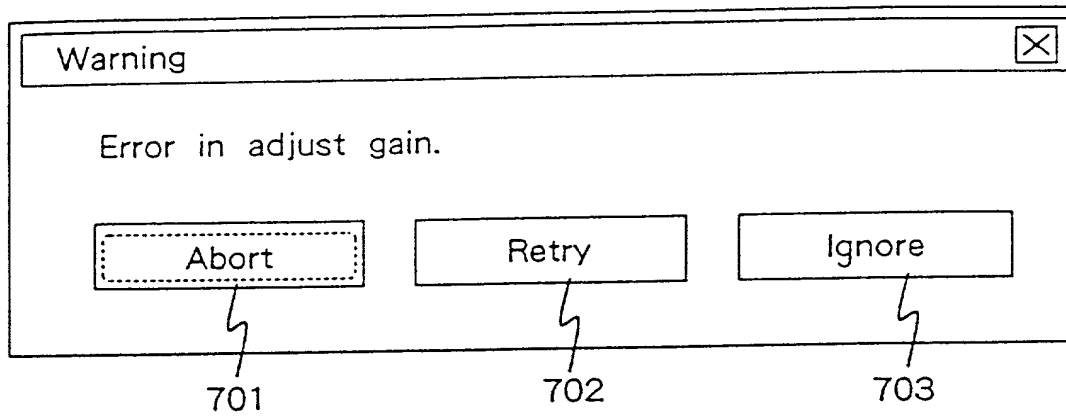
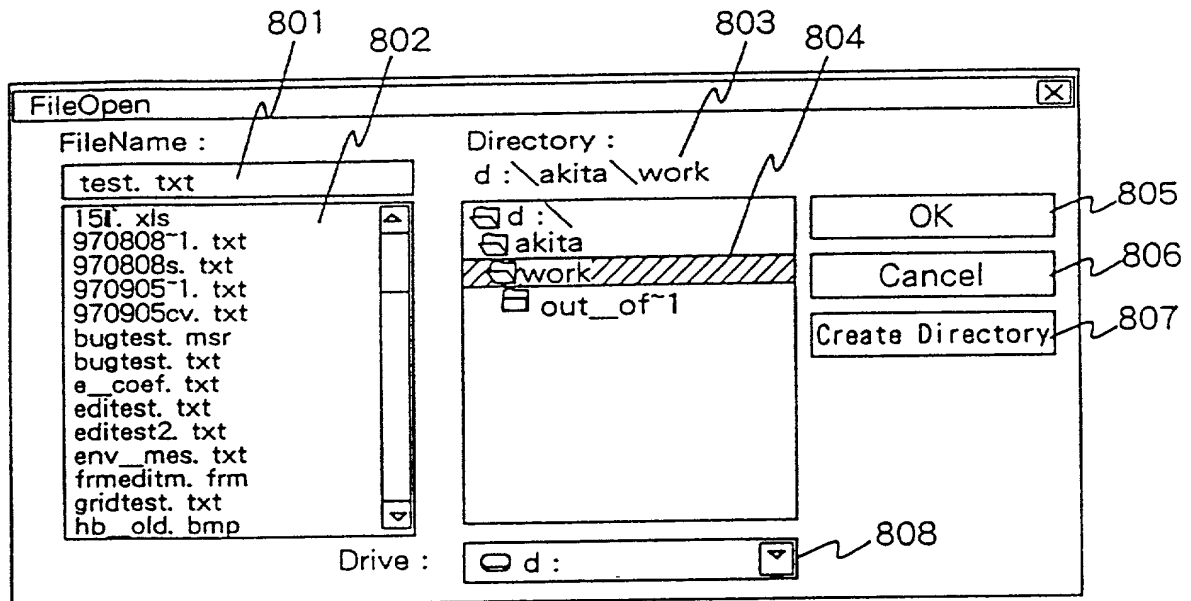


FIG. 8





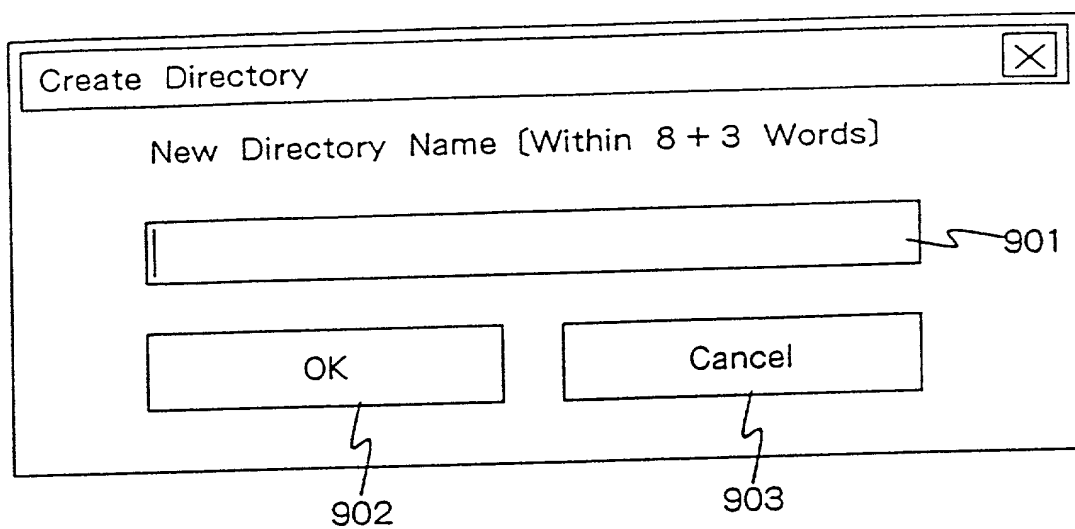
*FIG. 9*

FIG. 10

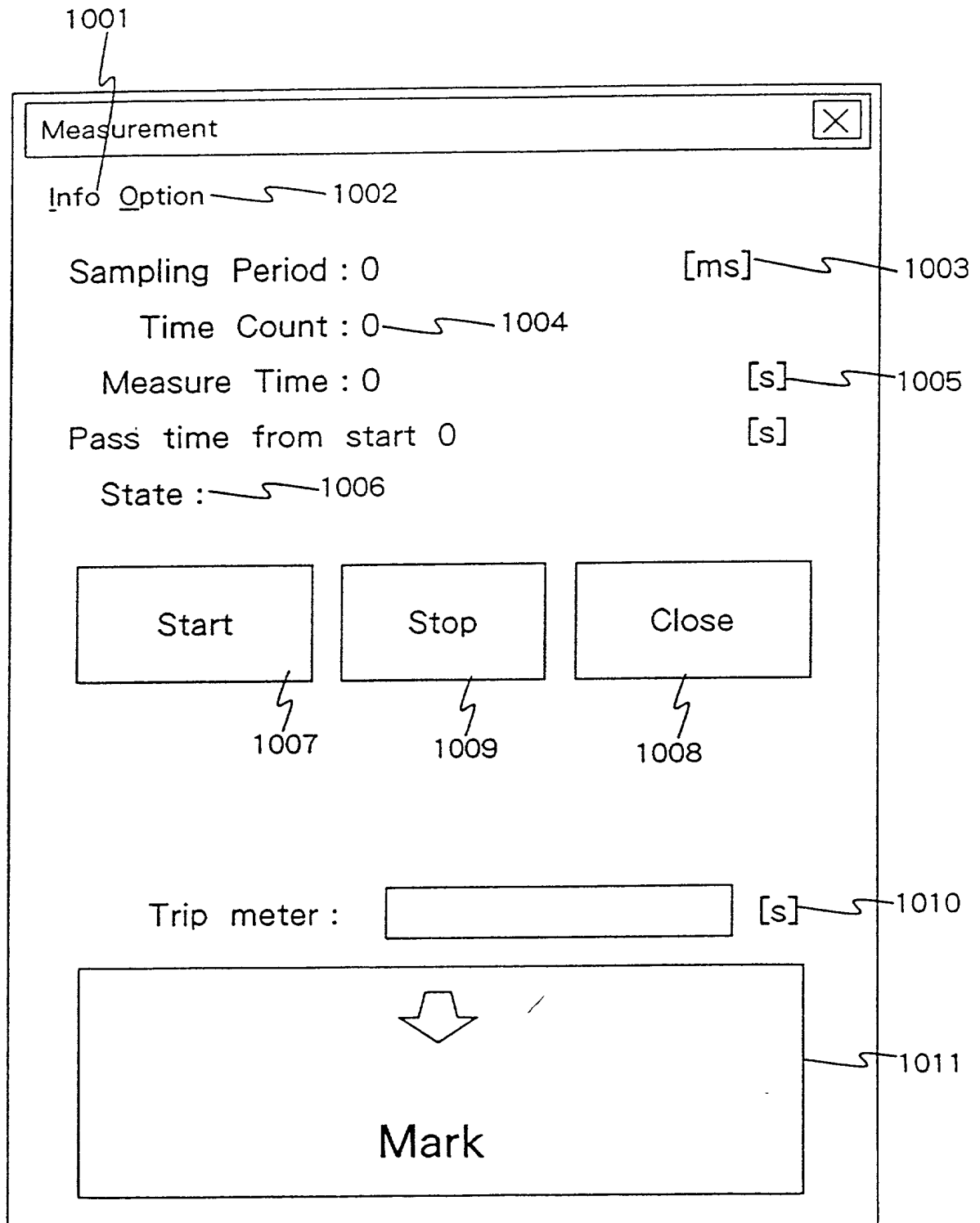


FIG. 11

The image shows a graphical user interface for a measurement tool. It features a main window with a title bar and a menu bar. The menu bar contains two items: 'Info' and 'Optin'. Below the menu bar is a large rectangular area containing two lines of text: 'Condition Ctrl + C' and 'Tuneup Ctrl + U'. At the bottom of the window is a section labeled 'Measure Time :'. The interface is designed with a simple, functional layout using black lines and text on a white background.

Measurement	
Info	Optin
<u>C</u> ondition	Ctrl + C
Tuneup	Ctrl + U
Measure Time :	

Figure 1 is a screenshot of a computer screen displaying a "Tuneup Option" window. The window has a title bar with "Tuneup Option" and a close button. Below the title bar is a menu bar with "File", "Edit", "Format", "Tools", "Window", and "Help". The main area of the window contains a table with the following columns: A/D CH, Use, Measure CH, Resource Type, Wavelength (nm), A/D Range (V), Lock in Amp Gain, and Visible. The table lists 24 channels (CH1 to CH47) with various settings. Below the table is a control panel with sections for "Insert box" (set to "True"), "A/D Range" (radio buttons for +/-5.00, +/-1.00, +/-0.10, +/-0.02), "Lock in Amp Gain" (radio buttons for 01, 02, 05, 10, 20, 50, 100), "Use" (radio buttons for True, False), and "Display Mode" (radio buttons for Each, All). "OK" and "Cancel" buttons are at the bottom right. Callout numbers 1202 through 1215 point to various elements.

A/D CH	Use	Measure CH	Resource Type	Wavelength (nm)	A/D Range (V)	Lock in Amp Gain	Visible
CH1	True	1	Optical	780	+/-1.00	1	True
CH3	True	2	Optical	780	+/-1.00	1	True
CH7	True	3	Optical	780	+/-1.00	1	True
CH5	True	4	Optical	780	+/-1.00	1	True
CH13	True	5	Optical	780	+/-1.00	1	True
CH9	True	6	Optical	780	+/-1.00	1	True
CH15	True	7	Optical	780	+/-1.00	1	True
CH11	True	8	Optical	780	+/-1.00	1	True
CH19	True	9	Optical	780	+/-1.00	1	True
CH17	True	10	Optical	780	+/-1.00	1	True
CH21	True	11	Optical	780	+/-1.00	1	True
CH23	True	12	Optical	780	+/-1.00	1	True
CH25	True	13	Optical	780	+/-1.00	1	True
CH27	True	14	Optical	780	+/-1.00	1	True
CH31	True	15	Optical	780	+/-1.00	1	True
CH29	True	16	Optical	780	+/-1.00	1	True
CH37	True	17	Optical	780	+/-1.00	1	True
CH33	True	18	Optical	780	+/-1.00	1	True
CH39	True	19	Optical	780	+/-1.00	1	True
CH35	True	20	Optical	780	+/-1.00	1	True
CH43	True	21	Optical	780	+/-1.00	1	True
CH41	True	22	Optical	780	+/-1.00	1	True
CH45	True	23	Optical	780	+/-1.00	1	True
CH47	True	24	Optical	780	+/-1.00	1	True

Control Panel:

- Insert box: True
- A/D Range:
  - ☐ +/-5.00
  - ☐ +/-1.00
  - ☐ +/-0.10
  - ☐ +/-0.02
- Lock in Amp Gain:
  - ☐ 01
  - ☐ 02
  - ☐ 05
  - ☐ 10
  - ☐ 20
  - ☐ 50
  - ☐ 100
- Use:
  - ☒ True
  - ☐ False
- Display Mode:
  - ☒ Each
  - ☐ All
- OK
- Cancel

*FIG. 13*

Measurement	
Option	
<u>G</u> raph	Ctrl + G
<u>B</u> ackup	Ctrl + B
<u>O</u> ther CH	Ctrl + O
Pre <u>S</u> can	Ctrl + S
<u>P</u> osition	Ctrl + P
<u>M</u> easure Parameter	Ctrl + M

State :

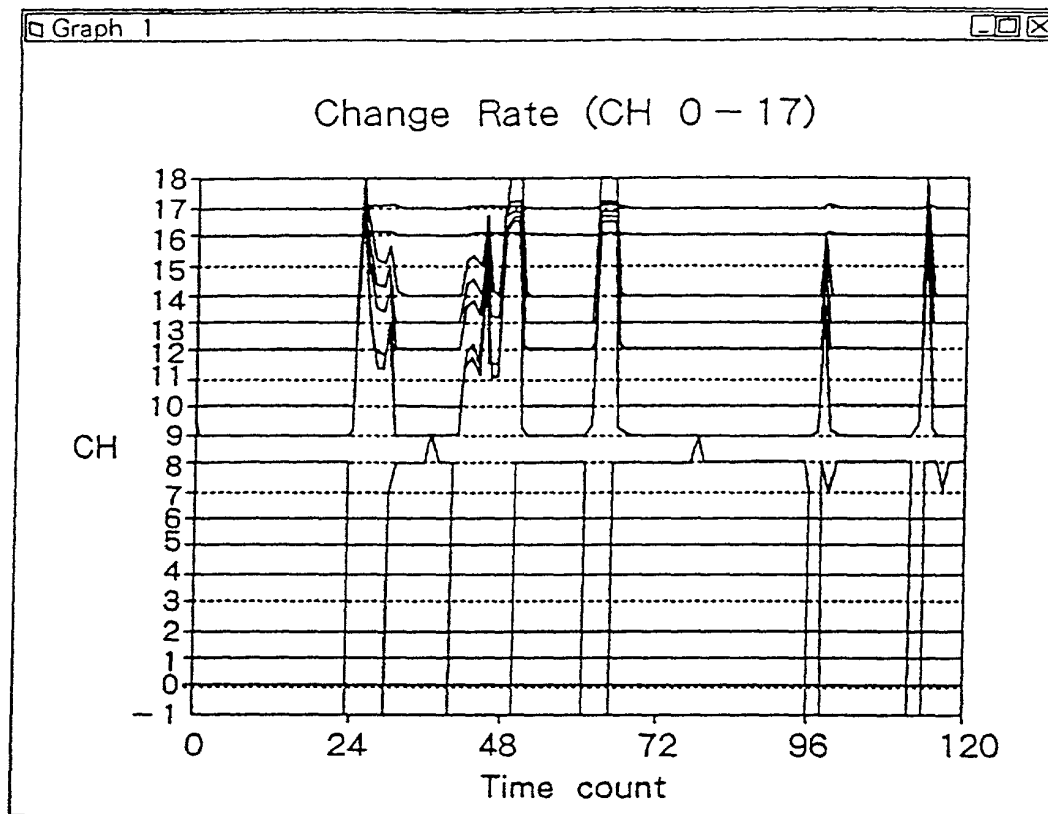


FIG. 15

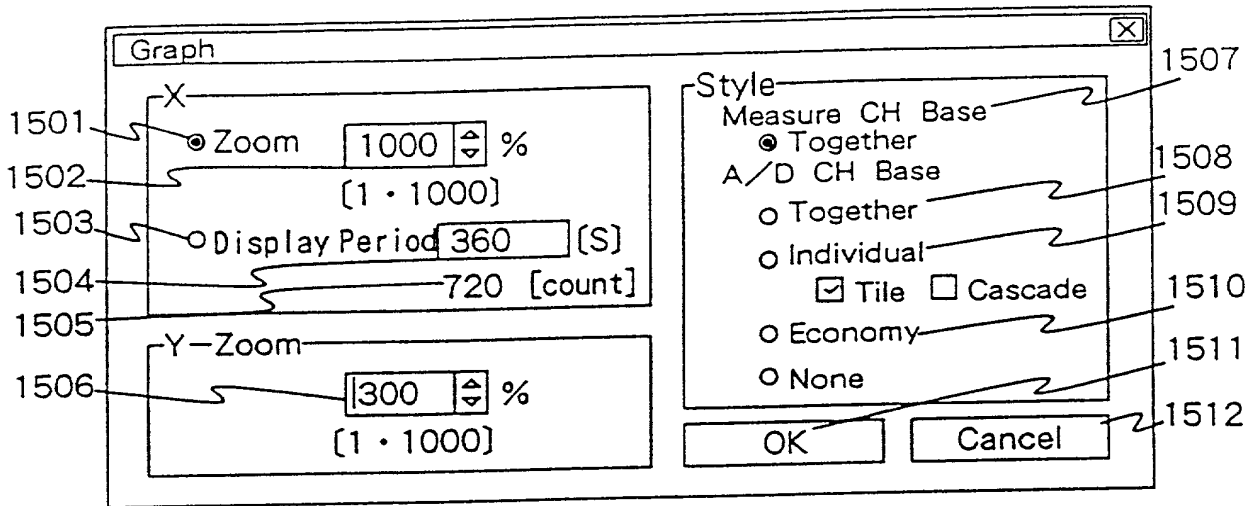


FIG. 16

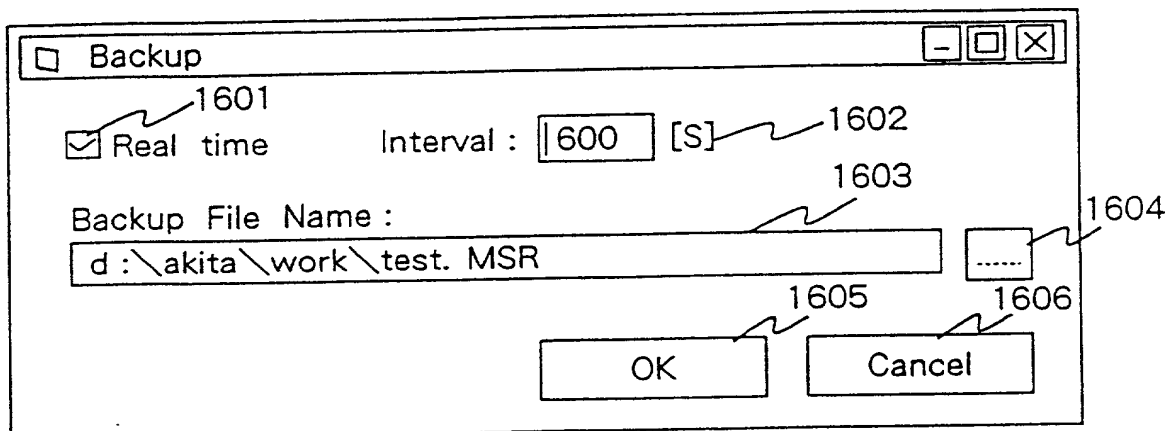


FIG. 17

The image shows a software dialog box titled "Other CH" with a close button (X) in the top right corner. The dialog contains the following elements:

- A label "A/D CH No of Other Input:" followed by a text input field containing the value "49". A squiggly line points from the reference number 1701 to the input field.
- A label "Resource Type:" followed by an empty text input field. A squiggly line points from the reference number 1702 to the input field.
- A label "A/D Range" followed by a group box containing four radio button options:
  - ☒  $\pm 5.00V$
  - ☐  $\pm 0.10V$
  - ☐  $\pm 1.00V$
  - ☐  $\pm 0.02V$A squiggly line points from the reference number 1703 to the group box.
- At the bottom, there are two buttons: "OK" and "Cancel". A squiggly line points from the reference number 1704 to the "OK" button, and another squiggly line points from the reference number 1705 to the "Cancel" button.



FIG. 18

Trigger pulse

☐ TriggerPulse 1801

Select COM

☒ COM 1 ☐ COM 2 1802

Initial pulse :  [S] 1803  times 1804

Length of cycle :  [S] 1805

Length of pulse :  [S] 1806

Length of Mark pulse :  [ms] 1807

OK 1808 Cancel 1809

FIG. 19

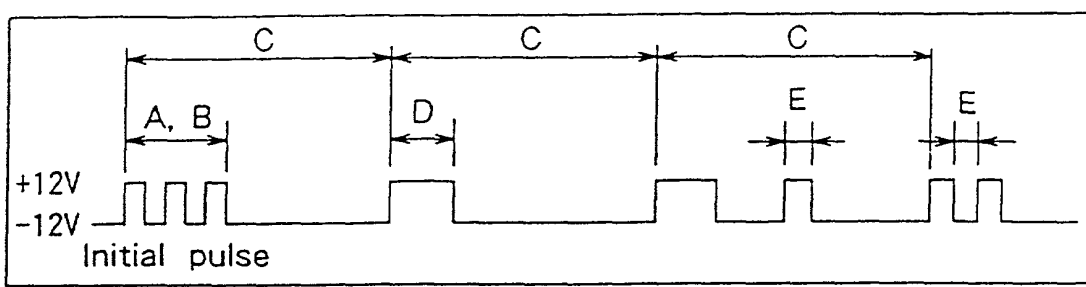


FIG. 20

External Trigger

☐ External Trigger

CH No of External Trigger Line

Length of Each Measure Time

Trigger level [0 - 5.0]

OK

Cancel

2001

2002

2003

2004

2005

2006

FIG. 21

Measure Parameter

Burst Rate : 48000 [Hz] 2101

Conversion Rate : 1000 [Hz] 2102

Number of Samples : 1 2103

Aquisition Time : 1 [ms] 2104

Sampling Period : 500 [ms] 2105

Total Time of Measurement

3600 [s] 2106

OK 2107

Cancel 2108

FIG. 22

FIG. 23

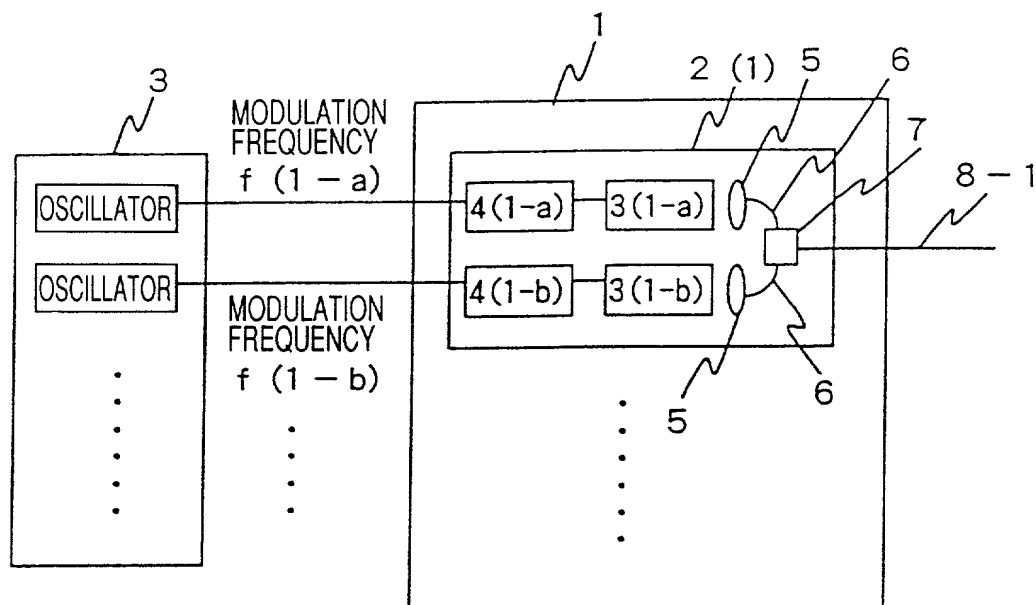
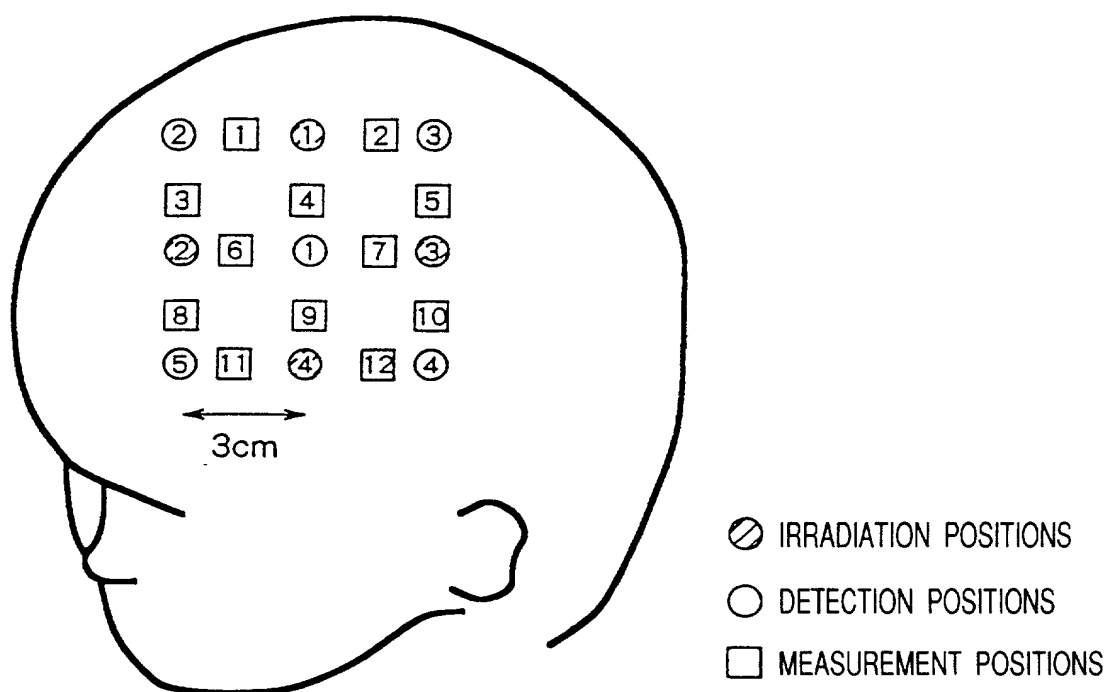


FIG. 24



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FIG. 25

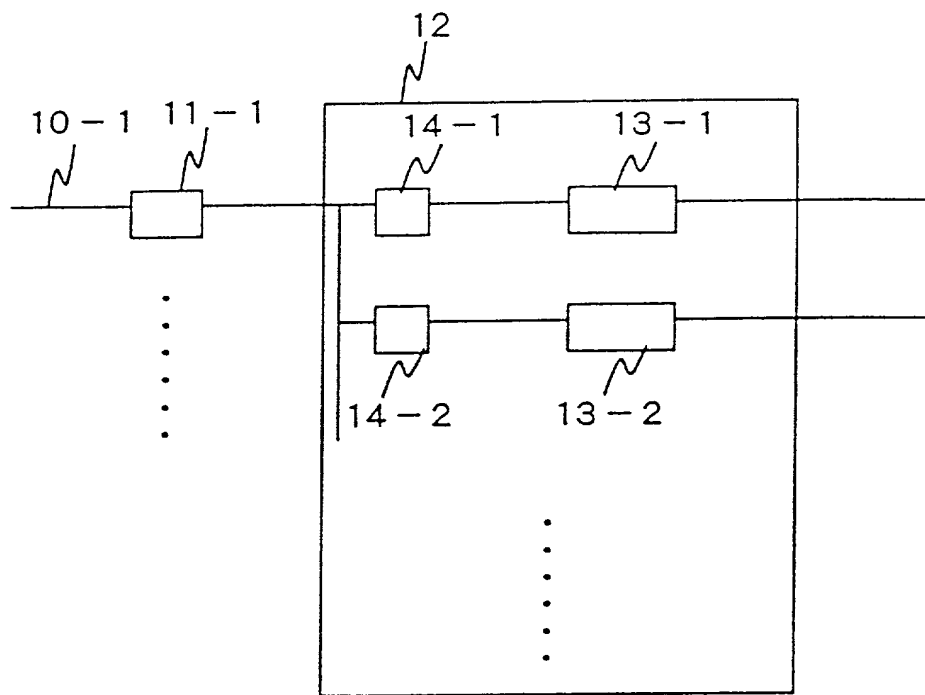


FIG. 26

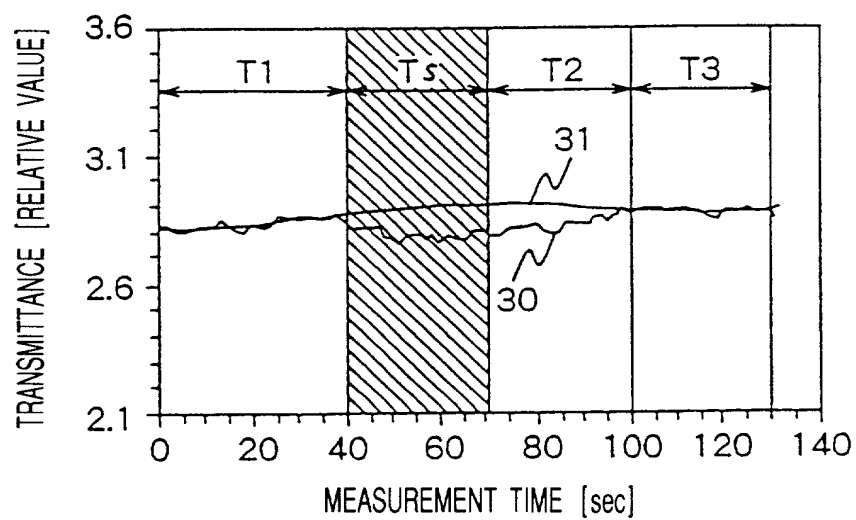


FIG. 27

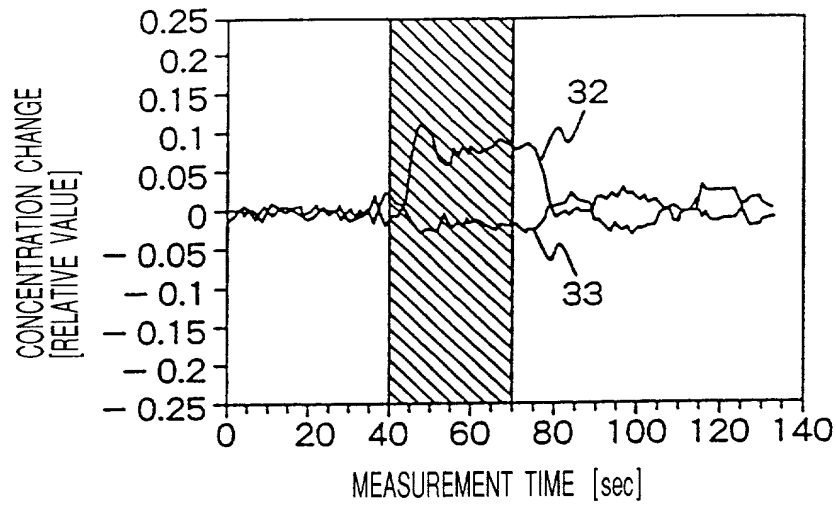
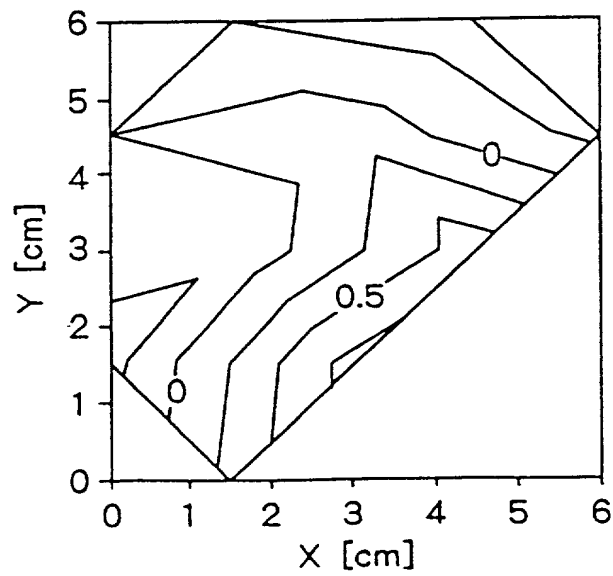
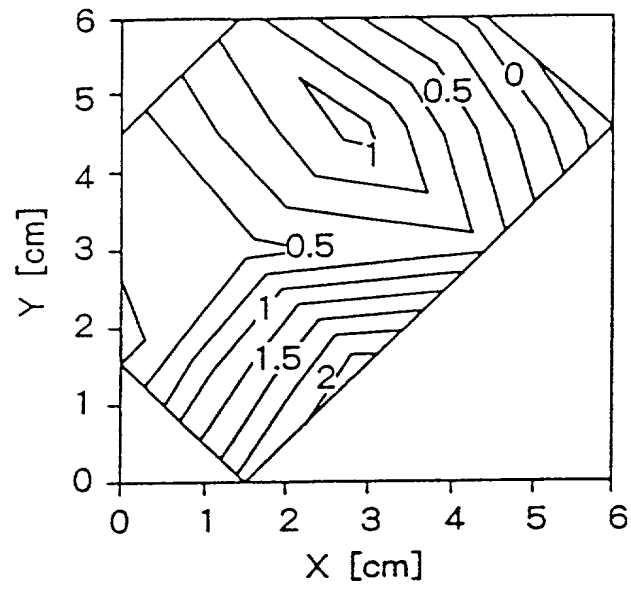
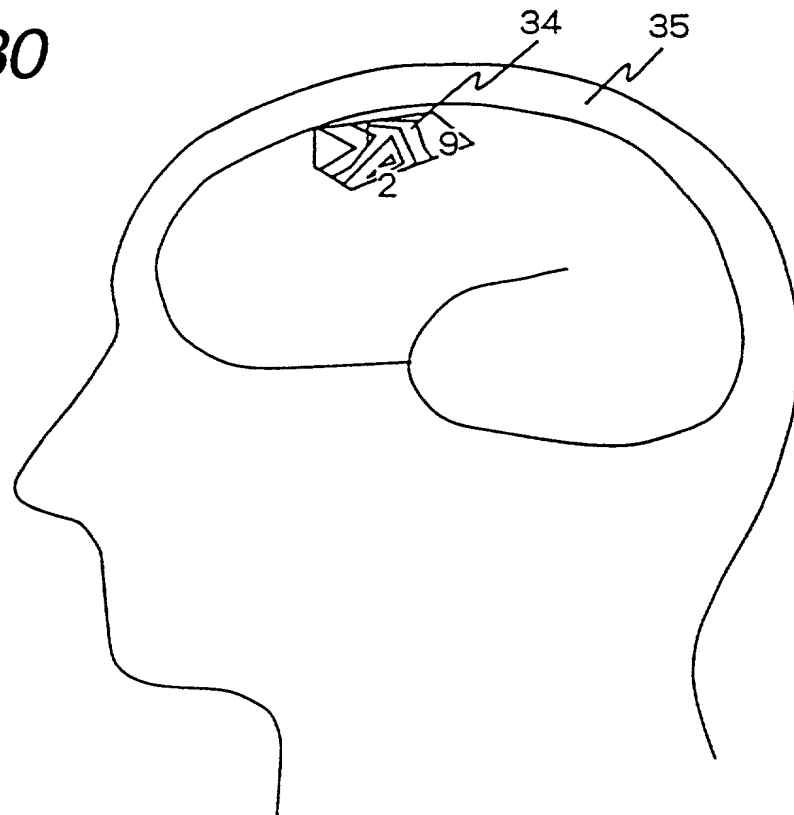


FIG. 28



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**FIG. 29****FIG. 30**



## Declaration and Power of Attorney For Patent Application

## 特許出願宣言書及び委任状

## Japanese Language Declaration

## 日本語宣言書

下記の氏名の発明者として、私は以下の通り宣言します。

As a below named inventor, I hereby declare that:

私の住所、私書箱、国籍は下記の私の氏名の後に記載された通りです。

My residence, post office address and citizenship are as stated next to my name.

下記の名称の発明に関して請求範囲に記載され、特許出願している発明内容について、私が最初かつ唯一の発明者（下記の氏名が一つの場合）もしくは最初かつ共同発明者であると（下記の名称が複数の場合）信じています。

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

OPTICAL MEASUREMENT INSTRUMENT AND

OPTICAL MEASUREMENT METHOD

上記発明の明細書（下記の欄で×印がついていない場合は、本書に添付）は、

The specification of which is attached hereto unless the following box is checked:

☐ 月 日に提出され、米国出願番号または特許協定条約国際出願番号を \_\_\_\_\_ とし、  
(該当する場合) \_\_\_\_\_ に訂正されました。

☒ was filed on 26 / April / 1999  
as United States Application Number or  
PCT International Application Number  
PCT / JP99 / 02207 and was amended on  
5 / October / 1999 (if applicable).

私は、特許請求範囲を含む上記訂正後の明細書を検討し、内容を理解していることをここに表明します。

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

私は、連邦規則法典第37編第1条56項に定義されたとおり、特許資格の有無について重要な情報を開示する義務があることを認めます。

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

## Japanese Language Declaration (日本語宣言書)

私は、米国法典第35編119条(a)-(d)項又は365条(b)項に基づき下記の、米国以外の国の少なくとも一カ国を指定している特許協力条約365(a)項に基づき国際出願、又は外国での特許出願もしくは発明者証の出願についての外国優先権をここに主張するとともに、優先権を主張している、本出願の前に出願された特許または発明者証の外国出願を以下に、枠内をマークすることで、示しています。

### Prior Foreign Application(s)

外国での先行出願

10-134649	Japan
(Number)	(Country)
(番号)	(国名)
<hr/>	
(Number)	(Country)
(番号)	(国名)

私は、第35編米国法典119条(e)項に基いて下記の米国特許出願規定に記載された権利をここに主張いたします。

(Application No.)	(Filing Date)
(出願番号)	(出願日)

私は、下記の米国法典第35編120条に基いて下記の米国特許出願に記載された権利、又は米国を指定している特許協力条約365条(c)に基づき権利をここに主張します。また、本出願の各請求範囲の内容が米国法典第35編112条第1項又は特許協力条約で規定された方法で先行する米国特許出願に開示されていない限り、その先行米国出願書提出日以降で本出願書の日本国内または特許協力条約国際提出日までの期間中に入手された、連邦規則法典第37編1条56項で定義された特許資格の有無に関する重要な情報について開示義務があることを認識しています。

(Application No.)	(Filing Date)
(出願番号)	(出願日)

(Application No.)	(Filing Date)
(出願番号)	(出願日)

私は、私自身の知識に基づいて本宣言書中で私が行なう表明が真実であり、かつ私の入手した情報と私の信じることに基づき表明が全て真実であると信じていること、さらに故意になされた虚偽の表明及びそれと同等の行為は米国法典第18編第1001条に基づき、罰金または拘禁、もしくはその両方により処罰されること、そしてそのような故意による虚偽の声明を行なえば、出願した、又は既に許可された特許の有効性が失われることを認識し、よってここに上記のごとく宣誓を致します。

I hereby claim foreign priority under Title 35, United States Code, Section 119 (a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed.

### Priority Not Claimed

優先権主張なし

28/April/1998	<input type="checkbox"/>
(Day/Month/Year Filed)	
(出願年月日)	
<hr/>	
(Day/Month/Year Filed)	<input type="checkbox"/>
(出願年月日)	

I hereby claim the benefit under Title 35, United States Code, Section 119(e) of any United States provisional application(s) listed below.

(Application No.)	(Filing Date)
(出願番号)	(出願日)

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s), or 365(c) of any PCT international application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code Section 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of application.

(Status: Patented, Pending, Abandoned)
(現況: 特許許可済、係属中、放棄済)

(Status: Patented, Pending, Abandoned)
(現況: 特許許可済、係属中、放棄済)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

## Japanese Language Declaration

(日本語宣言書)

委任状： 私は下記の発明者として、本出願に関する一切の手続きを米特許商標局に対して遂行する弁理士または代理人として、下記の者を指名いたします。(弁護士、または代理人の氏名及び登録番号を明記のこと)

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith (*list name and registration number*)

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第四共同発明者の署名	日付	Fourth inventor's signature 小泉 英明	Date 9/26/2000
住所	Residence Tokyo, Japan JPX		
国籍	Citizenship Japan		
私書箱	Post Office Address c/o Hitachi, Ltd., Intellectual Property Group New Marunouchi Bldg. 5-1, Marunouchi 1-chome, Chiyoda-ku, Tokyo 100-8220, Japan		
第五共同発明者名	Full name of fifth joint inventor, if any		
第五共同発明者の署名	日付	Fifth inventor's signature	Date
住所	Residence		
国籍	Citizenship		
私書箱	Post Office Address		